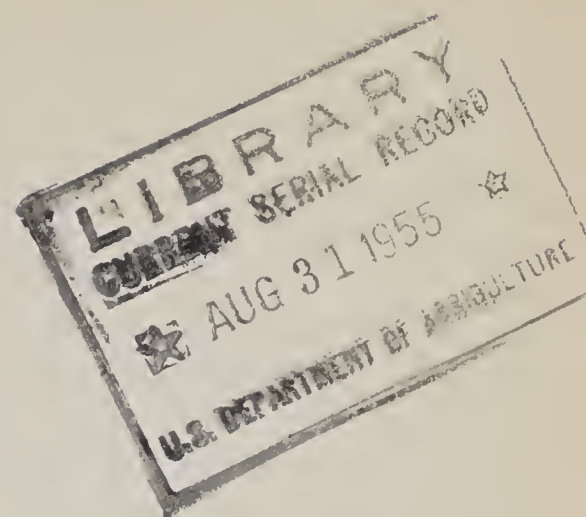


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U. S. Department of Agriculture
Entomology Research Branch
Agricultural Research Service
In cooperation with 15 cotton-growing States



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CONFERENCE REPORT
ON
COTTON INSECT RESEARCH AND CONTROL

Memphis, Tenn., December 14-15, 1953

(Seventh Annual Report)

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This is the seventh report to summarize results of conferences of State and Federal workers concerned with cotton insect research and control in the cotton-growing States. The conferences were held at:

Stoneville, Miss., on November 17-19, 1947
Baton Rouge, La., on November 8-10, 1948
Jackson, Miss., on November 28-30, 1949
Memphis, Tenn., on December 4-6, 1950
Memphis, Tenn., on December 2-4, 1951
Memphis, Tenn., on December 7-9, 1952
Memphis, Tenn., on December 14-15, 1953

Each report brings together the yearly results of research and experience in control of cotton insects. The seven reports indicate much of the progress made during the last seven years. In general, each supersedes the previous report, but each one contains information not given in other reports. These reports are not for general distribution. However, they are available, as long as the supply lasts, to entomologists and other research and extension workers, libraries, research agencies, the insecticide industry, and others interested in cotton production.

The results summarized herein should aid in the preparation of State recommendations issued for cotton-insect control for 1954.

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Research and extension entomologists and associated technical workers from 15 cotton-growing States (Alabama, Arizona, Arkansas, California, Florida, Georgia, Louisiana, Mississippi, Missouri, New Mexico, North Carolina, Oklahoma, South Carolina, Tennessee, and Texas), the United States Department of Agriculture, and the National Cotton Council of America participated in a conference at Memphis, Tenn., on December 14-15, 1953, to formulate a guiding statement for cotton-insect control recommendations in 1954 based on the research and experience of 1953 and previous years. Each section and sentence in this report was carefully considered and approved by the conference. The conferees are listed on pages 59 to 62. Cultural methods and the use of insecticides for controlling cotton pests are considered in this report.

Cultural control practices cannot be too strongly emphasized. It should be recognized that control of cotton insects with insecticides is really supplemental to good farm practices. Cultural control methods include such factors as early fall clean-up before frost where possible on farms infested with the boll weevil or pink bollworm, seed treatment, early planting, fertilization, use of proper cotton varieties, proper land use, and cultivation. Cultural measures used against cotton insects, depending upon the ones to be controlled, are influenced by climate, soil conditions, fertility, topography, and geographical location.

In addition to recommendations for the use of insecticides against cotton insects, this report presents information of value (1) to industry in planning production programs and (2) to State and Federal workers who cooperate with cotton growers in testing insecticides still in an experimental stage. It contains some suggestions as to research needs in developing more effective cotton-insect control programs. A general statement of plans is included, by which extension entomologists will aid in bringing to the attention of growers and all other interested groups the 1954 cotton-insect control recommendations for each State. Control recommendations are general and are not specifically fitted to local needs. In preparing recommendations for cotton insect control for 1954 each State should adapt to its own conditions the information given in this summary.

No restrictions are placed on the duplication of this report in whole or in part except in quoting, the material should not be removed from the context. If the report is not reprinted in its entirety, no less than a complete section relating to one material, or insect, and supplemental statements referred to therein, should be copied. No portion of this report should be used for advertising purposes.

Policy and Ethics

The chief purpose of the Cotton Insect Conference is to enable State and Federal entomologists to make readily available to each other information that may be useful in further research and extension work in cotton-insect control. This exchange of information makes mutual support possible.

While agreement on major recommendations may be expected, complete standardization is not possible. Details of recommendations must vary with requirements of the region or locality. Such variations are sometimes interpreted as disagreement among entomologists and can be a basis for confusion. To avoid this confusion, cotton growers should follow the advice of qualified entomologists in their respective States who are familiar with their local problems.

It should be recognized that procedures, equipment, and materials that may be effectively used in control of the various insect pests of cotton are now known. This knowledge adds to the stability of control recommendations. However, research is continued to find new procedures, equipment, or materials that may have advantages over those now in use. In bringing the results of new research to public attention, the impression that a panacea for all problems is being introduced tends to discredit all previous work and should be forestalled. It is desirable that results of research should not be reported to the public, or made a basis for recommendations, until they have been made available to other entomologists working in the same field.

In making recommendations for the use of insecticides, entomologists should recognize their responsibility with regard to the hazards to public safety and other interests involved in the use of such materials.

Unfortunately, various so-called boll weevil "remedies" have been put on the market through the years. Although some had slight value, usually most of them were less effective and more expensive than widely tested standard methods of insect control. Cotton growers are urged not to risk wasting money experimenting with unapproved devices, materials, or mixtures. Many cotton farmers are persuaded by salesmen to spend money in purchasing mixtures and machines that have little or no value in increasing yields or improving the quality of cotton.

Hazards and Precautions in the Use of Insecticides

Development of new synthetic organic insecticides provides more effective means of controlling insects, but numerous problems, such as hazard to man, domestic animals, crops, fish, and beneficial wild life, have been complicated by the use of these new chemicals, although many of them are actually not so toxic to man as are some of the old insecticides. Most insecticides may be harmful to man and animals if

used in excessive amounts or if handled carelessly; therefore, they should be used with appropriate precautions and in the amounts and manner recommended.

The factor of immediate toxicity of insecticides to the user, livestock, beneficial insects, and plants is of great importance. There is, in addition, the effect of chronic toxicity due to repeated exposures, of accumulations in soils, and of residues on treated plants and on adjacent crops caused by drift. Everyone concerned with insecticides and their use should be thoroughly familiar with these various hazards. Proper precautions should be taken when formulating, packaging, labeling, and applying these materials.

No organic phosphorus compound or other highly toxic material should be applied by aircraft or ground machines in such a manner that unprotected persons will be exposed to hazardous concentrations.

Packages of insecticides registered under State or Federal regulatory acts carry labels showing approved uses, unusual hazards, and antidotes if materials are highly poisonous. Users are therefore urged to read the label and follow directions explicitly.

Precautions for the User

In considering the hazards to man, it is necessary to distinguish between immediate hazards (acute toxicity) and the accumulative effects (chronic toxicity). Man can be poisoned by breathing most insecticides, by absorbing them through the skin, and by swallowing them.

Most solvents used in preparing solutions or emulsions are also poisonous. Some are inflammable. Research and experience indicate that the new chlorinated hydrocarbon insecticides are reasonably safe to man and higher animals at strengths normally applied for cotton-insect control. However, in concentrated form they may cause acute poisoning on prolonged contact with the skin or when swallowed. If emulsifiable concentrates are spilled on the skin or clothing, they should be washed off the skin immediately and a change to clean clothing should be made. Continued contact with or exposure to such materials may result in an injurious accumulation of the toxic ingredient in the body. Persons engaged in applying the insecticides after they are diluted or prepared for application to cotton for insect control should avoid unnecessary exposure to them. It is advisable to wear a respirator with suitable filter pads. Hands should be washed thoroughly before food is handled. Persons applying or handling insecticides should bathe and change clothing immediately after completing operation and also at least at the end of each working day if they are engaged in such operations on a full-time basis. This practice is especially important when working with emulsion concentrates.

Phosphorus compounds such as parathion, methyl parathion, EPN, TEPP, schradan, demeton, and Diazinon are extremely poisonous materials and must be handled with great care. It is not practicable to give all precautionary measures here that should be taken when phosphorus compounds are used. Such information is available through basic manufacturers, State experiment stations, or the Entomology Research Branch (formerly Bureau of Entomology and Plant Quarantine). All users should be thoroughly familiar with precautions and see that they are followed. Pickers and other workers should be kept out of treated fields for whatever period of time appears advisable, depending upon the material used and the local conditions at time of application.

An important precaution to observe is the avoidance of breathing wettable powders, dusts, sprays, or vapors. When handling or applying parathion, use a respirator that has been passed by the U. S. Department of Agriculture. In August 1951, a circular entitled "Respiratory Devices for Protection Against Inhalation Hazards of Dusts, Mists, and Low Vapor Concentrations of Certain Insecticides" was issued by the Bureau of Entomology and Plant Quarantine.

Loading and mixing should always be done in the open. Natural rubber gloves should be worn if it becomes necessary to handle the materials, but it is best to avoid unnecessary contact with insecticide sprays as well as dusts. Emulsifiable concentrates and wettable powders are especially dangerous.

It is advisable to have on hand in the field a change of clothing, soap and water, and a small supply of 1/100-grain atropine tablets for emergency use in phosphorus poisoning, as recommended by medical authorities. Quick action is essential in case any symptoms of poisoning appear. Regular users of the organic phosphorus compounds should have their blood cholinesterase checked periodically. Persons directing control operations should assume full responsibility for enforcement of adequate precautions and should have had medical advice as to the emergency use of atropine.

No insecticides should be spilled where they might contaminate food, feed, or water used by man or livestock.

Excess dusts or sprays, even in small quantities, should be deeply buried.

Empty containers in which insecticides have been packaged should be burned or otherwise destroyed as soon as empty. Insecticides should always be clearly identified by labels and stored where they are inaccessible to irresponsible persons or domestic animals.

The practice of either buying or selling insecticides in broken packages should be discouraged. However, where this is done there should be attached to the container a tag indicating the name of the insecticide and of the seller.

Equipment used for applying 2,4-D and other hormone-type weed killers should not be used for applying insecticides because of danger of crop injury.

Residues on Plants

Spraying or dusting should be done under conditions and in a manner to avoid excessive drift to adjacent fields where animals are pastured or where food crops are being grown. Care in preventing drift is also essential because certain varieties of plants and kinds of crops may be injured by some insecticides.

In developing and using systemic insecticides the possibility of residues remaining in cotton seed products should not be overlooked.

Cotton that has received late applications of DDT and certain other persistent insecticides should not be grazed by dairy cattle.

Residues in Soils

The effect of insecticides on germination, the rate of growth, and the flavor of crops may be influenced by the type of insecticide, the formulation used, the type of soil, the kind of plant, and/or the concentrations of the residues in the soil.

Information so far indicates that there is no immediate hazard to the plant growth of any crops when amounts and concentrations recommended for the control of cotton insects are followed. Injury to several crops has been demonstrated by higher rates of application of some insecticides as soil treatments on certain soil types. Soil applications of BHC, chlordane, and toxaphene may cause off-flavor of some crops. Cotton treated with foliage applications of BHC often causes off-flavor in Irish potatoes when this crop is planted in rotation with cotton.

Safeguarding Beneficial Forms of Life

Insecticides destroy beneficial as well as injurious insects. Some materials are highly toxic to fish and other forms of aquatic life. It is especially important to use minimum amounts where drift to ponds and streams is unavoidable. Every precaution should be taken to avoid the pollution of streams and farm ponds stocked with fish when excess spray or dust materials are being disposed of, or when equipment is being cleaned.

Preventing Honey Bee Losses

Insecticides applied to cotton may cause heavy losses to honey bees. Cotton produces excellent honey that would be lost without the activity of the honey bee. Furthermore, many cotton growers are also growing

legumes or other crops that require insect pollination. For the benefit of bee keepers, cotton growers, and agriculture in general, every effort should be made to protect pollinating insects.

The effect on honey bees should be considered whenever chemicals are applied. Any evaluation of the hazard of a particular application should take into account the toxicity of the insecticide to the bees, the amount applied per acre, and the exposure. Calcium arsenate, which kills colonies outright, is the most dangerous insecticide in wide use on cotton. Organic insecticides usually kill only the field bees without destroying the colony. Experience has shown, however, that some of these materials kill more bees than others. Parathion, EPN, malathion, BHC, lindane, and dieldrin are highly toxic to honey bees, and the bees should be moved if these materials are to be used. TEPP, heptachlor, chlordane, and probably aldrin may be used without hazard if extreme precautions are employed as to timing, dosage, and application. Toxaphene and DDT may be used with relative safety. Methoxychlor, Aramite, Ovotran, and sulfur are of little hazard.

Because organic insecticides kill chiefly by contact, applications should be made during the hours bees are not visiting the cotton.

To hold honey bee losses to a minimum, the following suggestions are made:

1. Treat only when insect infestation indicates chemical treatment is necessary.
2. Utilize nonchemical methods to their fullest to improve control and reduce the necessity for the use of insecticides.
3. Utilize careful scouting or supervised control to improve timing and to avoid unnecessary treatments.
4. Whenever possible, use the insecticides least toxic to bees.
5. Avoid drift into bee yards and adjacent crops in bloom.
6. Beekeepers should keep informed of cotton-insect infestations and recommendations for their control. This knowledge will enable them to locate bee yards in the safest available places and to know where and when insecticide applications are likely to be made. They should also contact the cotton growers before the insect-control season begins, giving the location of their apiaries and requesting the growers' cooperation.
7. Cotton growers should notify beekeepers at least 48 hours before dusting or spraying, so that all possible protective measures can be taken.
8. County agents and other agricultural leaders should also be given the exact location of apiaries. They could distribute such notification to beekeepers and recommendation of the materials least toxic to bees.

Honey bee losses can be reduced if better understanding and cooperation between beekeeper and cotton farmers is attained.

Insecticide Formulations

Dusts

New organic insecticides are used as toxicants in dust mixtures with carriers such as talcs, pyrophyllite, and clays, or in mixtures with other insecticides. Too much emphasis cannot be placed upon proper formulations.

Progress has been made in the formulation of good quality dusts for use on cotton. Poor results are often due to improper application or timing. Erratic results and poor control in some instances have been due to inferior dusting quality of the mixtures. Use of mixtures with excellent dusting qualities is in the interest of insecticide conservation and insect control. More information on insecticide formulations is needed to establish criteria for suitable dust mixtures of organic insecticides.

Sulfur as a diluent may give dust mixtures certain undesirable physical properties. Where spider mites are a problem, an appropriate amount of some suitable miticide is desirable in the mixture.

Sprays

Several organic insecticides have been applied widely as sprays since 1949. During this period results have proved that emulsion sprays of these insecticides will control cotton insects. Boll weevil control can be obtained with as little as 1 gallon or as much as 15 gallons of spray per acre with the toxicant remaining constant at the recommended rate. Most of the new organic insecticides are formulated as emulsifiable concentrates, which may be mixed with water to give emulsions suitable for application. Slight foliage burning has been noted in some instances when the emulsifiable concentrate was poorly formulated, or when the spray was poorly distributed.

Most oil solutions of insecticides cause foliage injury. Tests of experimental oils indicate that high viscosity, high volatility, and high aromatic content of the oil are the main factors causing foliage injury. Emulsifiers and solvents should be tested for toxicity to the cotton plant and their general suitability determined, before they are used in formulations. Phytotoxicity of the emulsions is also aggravated by high temperatures, high concentrations, and dry winds.

For stability in storage and to prevent breakdown of the formulation when metal containers are used, the containers should be lined with some material that will not react with or cause deterioration of the concentrate. It is undesirable to re-use metal containers for the packaging of emulsifiable concentrates. Used containers, especially 30- and 50-gallon drums, often have breaks in the linings. They are difficult to detect and will cause a breakdown of the formulation when it comes in

contact with the metal. Containers sometimes become contaminated with 2,4-D or 2,4,5-T on farms. Such contamination cannot always be detected and re-use of contaminated containers might prove very costly to the processor and to the farmer by damaging susceptible plants.

Some Aspects of Insecticide Applications

Application of insecticides to cotton may be made with both ground and aerial equipment. Regardless of equipment chosen, effective insect control is obtained only when applications are thorough and are properly timed. Improper and unnecessary applications often result in the development of a pest complex that can cause greater damage to the cotton crop than the one that originally required control.

Ground Application

Equipment is available for the ground application of dusts and sprays. Thorough distribution of them is essential for effective control of cotton pests.

Dusts.--For dust applications the nozzles should be adjusted to approximately 10 inches above the terminal growth of the cotton plants, with one nozzle over each row. Dusts should not be applied when the wind velocity exceeds 5 miles per hour.

Sprays.--For spraying of seedling cotton it is suggested that one nozzle per row be used, and as the cotton increases in size the number be increased to three. In the irrigated area as many as five nozzles may be used.

The nozzle should be adjusted to approximately 10 inches from the plants, and be capable of delivering from 1 to 8 gallons per acre, except in the Far West, where a greater quantity may be required. Sprays may be applied at wind velocities up to 15 miles per hour.

It is essential that emulsifiable concentrates be diluted immediately before use with not to exceed an equal volume of water, and the emulsion then added to the required volume of water. Some type of agitation, generally the by-pass flow, is necessary during the spray operation to insure a uniform mixture.

As a safety measure it is recommended that the spray boom be located behind the operator.

Aerial Application

Aerial application of insecticides may be made either as a dust or as a spray. Results of experiments have shown that either will effectively control cotton insects when properly applied.

Certain general principles are applicable to either dusts or sprays. The width of each swath should be limited to the plane's wing span or approximately 40 feet. A method of flagging or marking should be used to secure proper distribution of the insecticide and effective control of cotton pests.

Dusts. -- Properly formulated insecticides of free flowability should be used to obtain even distribution. Applications should be made when the wind velocity does not exceed approximately 4 miles per hour.

Sprays. -- Emulsifiable concentrates should be mixed with water to the desired dilution immediately before loading the plane. Planes should be equipped with standard nozzles or other atomizing devices which will produce droplets within the range of 100 to 300 microns. This equipment should also minimize excessively large or small droplets. It should be equipped to deliver from 1 to 4 gallons of spray mixture per acre depending on local conditions, except in the Western areas where greater quantities may be required.

Sprays may be applied during periods of wind velocity up to 10 miles per hour.

Timing of Applications

With presently available insecticides, successful control of cotton insects depends more on correct timing of applications than on any other factor. Consideration must be given to the overall population and stage of beneficial and harmful insects rather than to a single pest. The stage of growth of the cotton plant and expected yield are important.

Most insecticides kill predatory and parasitic insects as well as pest insects. Since use of insecticides often appears to induce outbreaks of bollworms, aphids, and spider mites, it is essential that insecticides be applied only where and when needed.

It is generally recommended that early-season applications be made to control cutworms, beet armyworms, darkling ground beetles, grasshoppers, or aphids when these insects threaten to reduce a stand.

Recommendations for early-season applications against thrips, boll weevils, fleahoppers, and plant bugs vary greatly from State to State. Differences in early-season infestations of these insects as well as many other production factors make it undesirable to attempt to standardize recommendations for early-season control.

It is likewise generally recommended that suitable insecticides be applied to cotton in its maximum period of fruiting and maturing of the crop, if insect infestations threaten to reduce the yield, seriously affect quality, or delay maturity. Recommendations for insecticide treatments are similar throughout the Cotton Belt, but certain details differ from State to State, and often within the State.

Insecticides and Miticides

Aldrin

Aldrin will control the boll weevil, thrips, the cotton fleahopper, the tarnished plant bug, the rapid plant bug, grasshoppers, the fall armyworm, and lygus bugs. It will not control the bollworm, the pink bollworm, the yellow-striped armyworm, the cotton leafworm, the garden webworm, certain species of cutworms and most other lepidopterous larvae, the cotton aphid, or spider mites. The use of aldrin may result in increased populations of spider mites, and mixtures of aldrin and DDT may increase those of aphids. For boll weevils, aldrin should be applied at the rate of 0.25 to 0.75 pound per acre. In areas or at times when bollworms are a problem, DDT should be added to aldrin in a 2:1 ratio. It is effective in a dust or spray.

Aldrin is toxic by skin absorption, by inhalation, and by ingestion. It is recommended for use on cotton only where persons applying it are fully aware of the hazards and will follow the precautions prescribed by the manufacturers.

See Hazards and Precautions in the Use of Insecticides, p. 5.

Aramite

Aramite will control spider mites when applied at 0.33 to 1 pound of technical material per acre in either dusts or sprays. Two applications at 7-day intervals may be required to give control. It may also be used in spray mixtures with insecticides. Aramite is compatible with sulfur, but special care should be used in the preparation of formulations. Aramite has essentially no insecticidal activity.

BHC (benzene hexachloride)

BHC will control the boll weevil, lygus bugs, the rapid plant bug, thrips, stink bugs, the garden webworm, the fall armyworm, the cotton fleahopper, and grasshoppers. It will not control the bollworm, the pink bollworm, the yellow-striped armyworm, spider mites, some species of cutworms, and the salt-marsh caterpillar. It is effective in a dust or spray. It has given erratic results against the cotton leafworm and the cotton aphid in some areas.

Except for use in early-season control, BHC is usually formulated with DDT in a 3:1 ratio in both dusts and sprays for use in overall cotton-insect control. This mixture should be applied at the rate of 0.3 to 0.45 pound of the gamma isomer and 0.5 to 0.75 pound of DDT per acre. In some of the western areas a popular formulation has been 2 parts of the gamma isomer to 5 parts of DDT. Where spider mites are a problem,

the dust usually contains at least 40 percent of a good grade of dusting sulfur. Other dusts contain either 2 or 3 percent of the gamma isomer of BHC and 10 percent of DDT. Sprays should be formulated to contain the same amounts of each active ingredient per acre as the dusts. It is very important that the emulsifiable concentrate containing BHC be properly formulated to prevent foliage or plant injury.

It is not advisable to use BHC in controlling pests on cotton which will be alternated with such crops as Irish potatoes and possibly other root crops.

BHC is toxic to warm-blooded animals. It may enter the body through absorption, inhalation, or ingestion. Proper precautions in its use should therefore be observed.

See Hazards and Precautions in the Use of Insecticides, p. 5, and Residues in Soils, p. 8.

Calcium Arsenate

Calcium arsenate has excellent dusting qualities and is an economical and effective insecticide for control of the boll weevil and the cotton leafworm. It is used at the rate of 7 to 10 pounds per acre. Against bollworms 12 to 15 pounds per acre will give only fair control, if applications are properly timed. Generally it is used undiluted against these insects. It often causes an increase in aphid population when used without an aphidicide. Alternate applications of calcium arsenate and a formulation containing an aphidicide have given excellent results in some areas.

Low-lime calcium arsenate is compatible with organic insecticides. In some areas when it is combined with 5 percent of DDT and 1 percent of parathion (see precautions under parathion), boll weevils, bollworms, cotton aphids, and spider mites are controlled. Low-lime calcium arsenate in combination with these materials should be applied at the rate of 10 to 12 pounds per acre.

Calcium arsenate is injurious to some crops, especially legumes and oats in certain light sandy soils. It should not be used for cotton-insect control in fields where rice may be planted. Drifting of the dust may injure other crops. Precautions should be taken to avoid drift that might cause bee losses. Calcium arsenate is poisonous and should be handled carefully. Livestock should be kept out of dusted fields. Care should be taken to avoid drift onto pastures, especially when applications are made by airplane.

See Hazards and Precautions in the Use of Insecticides, p. 5.

Chlordane

Chlordane has given good results against the cotton fleahopper, the rapid plant bug, the fall armyworm, the field cricket, grasshoppers, the sand wireworm, darkling ground beetles, and thrips. Results against

the boll weevil and lygus bugs have not been consistent. It will not control the bollworm, the pink bollworm, the yellow-striped armyworm, the cotton aphid, stink bugs, or spider mites.

For the insects against which chlordane is effective, from 0.2 to 2 pounds of the technical material per acre is required.

When used in mid- or late-season treatments for overall cotton-insect control, chlordane should always be formulated with DDT in a 2:1 ratio. From 1 to 1.5 pounds of technical chlordane and 0.5 to 0.75 pound of technical DDT per acre should be applied. It is effective in a dust or spray.

The populations of cotton aphids and spider mites may increase to damaging proportions after applications of chlordane-DDT sprays and dusts. Careful inspections for these two pests should be made at weekly intervals after such applications. If the numbers of either species increase, appropriate measures should be taken to control them as outlined under the respective pests.

See Hazards and Precautions in the Use of Insecticides, p. 5.

DDT

DDT will control the bollworm, the tobacco budworm, the pink bollworm, the fall armyworm, the tarnished plant bug and other lygus bugs, the garden webworm, the cotton leaf perforator, the western yellow-striped armyworm, the beet armyworm, darkling ground beetles, flea beetles, the white-lined sphinx, the green stink bug, the southern green stink bug, the rapid plant bug, the cotton fleahopper, and thrips. In some instances, unsatisfactory results against thrips have been reported when the temperature exceeded 90° F. It will also control certain species of cutworms, and to a lesser extent the yellow-striped armyworm. It will not control the boll weevil, the cotton leafworm, the cabbage looper, the salt-marsh caterpillar, spider mites, the cotton aphid, the Say stink bug, and grasshoppers.

In a dust on cotton, DDT is ordinarily used at the rate of 0.5 to 3 pounds of technical DDT per acre, either alone or mixed with other insecticides and miticides. Sprays and dusts containing DDT are about equal in effectiveness against cotton pests.

Aphid and mite populations may increase until they cause severe injury where DDT is used, unless an aphidicide or a miticide is included in the formulation.

DDT is toxic to certain plants such as cucurbits. Its toxicity persists and accumulates in the soil. Therefore, it should be used only in the minimum amounts recommended for cotton-insect control, especially on light sandy soils. Contamination of adjacent crops from drift should be avoided.

Acute toxicity of DDT to man and animals is rather low compared with that of inorganic insecticides now used on cotton. However, when DDT is repeatedly ingested or brought into contact with the skin, it may be absorbed and stored in the fatty tissues. Injury to the liver may also result. Unnecessary exposure of operators should be avoided.

See Hazards and Precautions in the Use of Insecticides, p. 5.

Demeton (Systox)

Demeton, the principal active ingredient in Systox, is both a systemic and a contact insecticide. When applied in a foliage spray, it is effective against cotton aphids and spider mites for a period of from 2 to 8 weeks at dosages from 0.125 to 0.40 pound per acre. For soil treatment 2 to 4 pounds per acre are required, and for seed treatment 0.25 to 0.50 pound per 100 pounds of seed. It does not control the boll weevil, the bollworm, the cotton leafworm, thrips, the pink bollworm, or grasshoppers.

Demeton is a dangerous poison. It is much more toxic to warm-blooded animals than most poisons used in cotton-insect control. Therefore, it should be handled with extreme caution, and the directions prescribed by manufacturers should be strictly followed.

See Hazards and Precautions in the Use of Insecticides, p. 5.

Dieldrin

Dieldrin will control the boll weevil, thrips, stink bugs, the cotton fleahopper, lygus bugs, the rapid plant bug, the fall armyworm, grasshoppers, the variegated cutworm, the pale-sided cutworm, the granulate cutworm, the black cutworm, the yellow-striped armyworm, and the garden webworm. It is not effective at low dosages for bollworm control and DDT should be added when control of this insect is necessary. The numbers of spider mites and aphids may increase where dieldrin is used. Against boll weevils dieldrin should be applied at the rate of 0.15 to 0.5 pound per acre. It will kill newly hatched cotton leafworms at dosages effective against the boll weevil. It is effective either in a dust or spray.

Dieldrin is toxic by skin absorption, by inhalation, and by ingestion. It is recommended for use on cotton only where persons applying it will follow the precautions prescribed by the manufacturers.

See Hazards and Precautions in the Use of Insecticides, p. 5.

Endrin

Endrin was used experimentally in a spray for cotton-insect control in many locations throughout the Cotton Belt in 1952 and 1953 and was

recommended for this control in a few States in 1953. It is effective against the boll weevil, the bollworm, the salt-marsh caterpillar, the cabbage looper, lygus bugs, and the cotton leafworm, when applied at the rate of 0.2 to 0.5 pound per acre; against thrips, the cotton fleahopper, and the cotton leaf perforator at 0.08 to 0.15 pound. Endrin did not control spider mites, or the pink bollworm. Aphids did not build up after its widespread use in 1952 and 1953.

The acute toxicity of endrin is considerably higher than that of dieldrin. It is toxic by skin absorption, by inhalation, and by ingestion. It is recommended for use on cotton only where persons applying it will follow the precautions prescribed by the manufacturers.

See Hazards and Precautions in the Use of Insecticides, p. 5.

Heptachlor

Heptachlor will control the boll weevil, the cotton fleahopper, the garden webworm, grasshoppers, and lygus bugs. Against these insects heptachlor should be applied at the rate of 0.20 to 0.75 pound per acre, either in a dust or spray. It is effective against thrips when applied at 0.08 to 0.15 pound. Spider mite and aphid populations may increase where heptachlor or heptachlor-DDT mixtures are used. It will not control the bollworm, the yellow-striped armyworm, the pink bollworm, the cotton aphid, or spider mites.

See Hazards and Precautions in the Use of Insecticides, p. 5.

Lead Arsenate

For about fifty years, roughly from 1895 to 1945, lead arsenate was the best known and most widely used insecticide. For use on cotton against the cotton leafworm, the bollworm, and the boll weevil it was for many years a close competitor of paris green until calcium arsenate was used in 1916. Lead arsenate is still used at times against the cotton leafworm and in baits for cutworms. In general, along with the other arsenicals, it has been replaced by organic insecticides.

Lindane

Lindane, the essentially pure gamma isomer of BHC, may be substituted on an equivalent-weight basis for the gamma isomer of BHC in formulations of insecticides used on cotton insects. Laboratory and field tests indicate that lindane is slightly less effective than technical BHC when used for cotton aphid control.

Lindane dusted or slurried onto planting seed at the rate of 1 to 2 ounces of technical material per 100 pounds of seed will control wireworms, seed-corn maggots, and false wireworms. The use of fungicides

is not covered in this report, but extensive results indicate that a suitable fungicide should be included with lindane seed treatment.

Lindane is toxic to warm-blooded animals. It may enter the body through absorption, inhalation, or ingestion. Proper precautions should therefore be observed in its use.

See Hazards and Precautions in the Use of Insecticides, p. 5.

Methoxychlor

Dusts containing 10 percent of methoxychlor controlled the cotton leafworm, but lower concentrations gave poor control.

Methoxychlor gave slightly better control of the pink bollworm than DDT, but a heavy buildup of aphids usually followed its use and it failed to control bollworms. Therefore, it is not being generally used for pink bollworm control.

Methoxychlor is less effective than the insecticides now recommended for the control of the boll weevil, the bollworm, the cotton aphid, the garden webworm, spider mites, and stink bugs. It is less toxic than DDT to warm-blooded animals, and is less likely to be stored in the fat or excreted in the milk.

See Hazards and Precautions in the Use of Insecticides, p. 5.

Nicotine

Two percent of nicotine in calcium arsenate alternated with applications of calcium arsenate alone will usually prevent a cotton aphid buildup, if properly applied. The period between nicotine applications should not exceed 8 to 10 days.

Three percent of nicotine at 10 to 15 pounds per acre in a suitable carrier can be used to knock out heavy aphid infestations. At least 0.3 pound per acre of free-nicotine equivalent should be applied. The source may be either nicotine sulfate or a fixed nicotine in dust form. It should be applied when the air is calm and preferably when there is no dew on the plants. Complete coverage is essential.

Nicotine is highly toxic to man and animals and should be used with adequate precautions.

See Hazards and Precautions in the Use of Insecticides, p. 5.

Parathion

Parathion will control the cotton aphid, some species of spider mites, (see p. 40), the garden webworm, leaf hoppers, and the cotton leafworm when applied at the rate of 0.10 to 0.50 pound of the technical material per acre. It may be applied in a dust or spray alone or in combination with other insecticides. It gives very little control of the boll weevil,

the fall armyworm, the variegated cutworm, the bollworm, and the pink bollworm. Bollworm infestations sometimes increase after applications of parathion.

Parathion is a dangerous poison. It is much more toxic to warm-blooded animals than most poisons used in cotton-insect control. Therefore, it should be handled with extreme caution and the directions prescribed by the manufacturers should be strictly followed.

See Hazards and Precautions in the Use of Insecticides, p. 5.

Paris green

This arsenical was the first insecticide to be widely used on cotton. Many million pounds were used between 1870 and 1910 for the control of the cotton leafworm, and to a less extent of the bollworm and the boll weevil. Although it is still used in emergencies to control the cotton leafworm, for general use on cotton it was succeeded by lead arsenate and calcium arsenate and later by organic insecticides.

Rotenone

One percent of rotenone in calcium arsenate at each application made against the boll weevil gives satisfactory control of the cotton aphid.

Sulfur

Sulfur has been widely used in dust mixtures on cotton for control of certain species of spider mites and the cotton fleahopper. It has a repressive effect upon aphid populations in some areas. Where the desert spider mite (see p. 40) is a problem, at least 40 percent of sulfur should be included in all dust mixtures to prevent the development of damaging infestations of this species and as a depressant of the others. Sulfur is most effective when finely ground and when maximum temperatures are 90° F. or above.

TEPP (tetraethyl pyrophosphate)

TEPP at the rate of 0.5 to 1 pint of the 40-percent concentrate per acre, or its equivalent, will control cotton aphids and some species of spider mites when used on dry plants at proper intervals. Several applications may be required for spider mite control.

This chemical deteriorates rapidly when exposed to moisture or moist air and is incompatible with alkaline materials. It should be applied immediately after being mixed with water. Residual toxicity of the chemical is very short.

TEPP is a dangerous poison. It is much more toxic to warm-blooded animals than most poisons used in cotton-insect control. Therefore, it should be handled with extreme caution and the directions prescribed by the manufacturers should be strictly followed.

See Hazards and Precautions in the Use of Insecticides, p. 5.

Toxaphene

Toxaphene will control the boll weevil, the fall armyworm, the garden webworm, the cabbage looper, the tarnished plant bug, the rapid plant bug, cutworms, lygus bugs, cotton aphids, the salt-marsh caterpillar, and the cotton leaf perforator, when applied at the rate of 1 to 5 pounds of technical material per acre. Within this dosage range it is less effective against the bollworm and the yellow-striped armyworm. It will control the cotton fleahopper, thrips, grasshoppers, and the cotton leafworm when applied at 0.75 to 2.5 pounds per acre. When properly applied, dusts and sprays are about equally effective in most areas.

Control of the bollworm, the salt-marsh caterpillar, and the cotton leaf perforator is improved where DDT applied at the rate of 0.25 to 1 pound per acre, is incorporated in the toxaphene spray mixture. Toxaphene alone will not give adequate control of the pink bollworm. It will not control heavy infestations of aphids or spider mites. When used for the control of other insects, it has a repressive effect upon aphid populations, but this repression may not be sufficient to prevent aphid outbreaks in some areas. Where spider mites are a problem, at least 40 percent of sulfur should be included in dust mixtures to prevent development of damaging infestations of sulfur-susceptible species and to serve as a depressant of other species.

See Hazards and Precautions in the Use of Insecticides, p. 5.

Insecticides and Miticides That Show Promise for Commercial Use and Are Recommended for Large-Scale Field Trials in 1954

Chlorthion

Chlorthion (O-(3-chloro-4-nitrophenyl) O,O-dimethyl thiophosphate) differs from methyl parathion only in having a chlorine atom in place of hydrogen in the meta position on the benzene ring. This compound is reported to be less toxic to warm-blooded animals than several other phosphorus compounds. It was tested against the boll weevil, the bollworm, the cotton leafworm, the cotton aphid, and spider mites in laboratory and field cages and in field plots in 1952 and 1953. It will control the boll weevil at dosages ranging from 0.25 to 1.0 pound of the technical material per acre, and the cotton aphid and the cotton leafworm at 0.25 to 0.5 pound per acre. At these last dosages spider mites were held in check.

Field experience with chlorthion has been limited. Special precautions should be exercised in its use until more is known about its toxicity to man and animals.

See Hazards and Precautions in the Use of Insecticides, p. 5.

Diazinon

Diazinon (O,O-diethyl O-(2-isopropyl-6-methyl-4-pyrimidinyl) thiophosphate) appears promising for the control of spider mites and cotton aphids at dosages between 0.125 and 0.5 pound of the technical material per acre.

Diazinon is a dangerous poison. It is much more toxic to warm-blooded animals than most poisons used in cotton-insect control. Therefore, it should be handled with extreme caution and the directions prescribed by the manufacturers should be strictly followed.

See Hazards and Precautions in the Use of Insecticides, p. 5.

EPN

EPN (O-ethyl O-p-nitrophenyl benzenthiosphosphate) was used experimentally for cotton-insect control in 1952 and 1953. It is effective against the boll weevil when applied at a rate of 0.5 to 0.75 pound per acre; against the yellow-striped armyworm at 0.3 pound per acre, and against thrips, the cotton fleahopper, the cotton leafworm, and some species of spider mites at 0.25 pound per acre. Aphids and bollworms may build up to damaging numbers after its use, but spider mites do not.

A mixture of EPN and DDT was more effective against the pink bollworm than DDT alone. EPN at the rate of 1 pound per acre showed promise for pink bollworm control.

EPN is a dangerous poison. It is much more toxic to warm-blooded animals than most poisons used in cotton-insect control. Therefore, it should be handled with extreme caution and the directions prescribed by the manufacturers should be strictly followed.

See Hazards and Precautions in the Use of Insecticides, p. 5.

Isodrin

Isodrin has been tested for cotton-insect control during the last three years. It will control thrips, the cotton fleahopper, and the cotton leafworm, but not the bollworm, the tobacco budworm, the fall armyworm, the yellow-striped armyworm, the pink bollworm, aphids, and spider mites. In South Carolina isodrin applied at 0.2 to 0.4 pound per acre gave satisfactory control of the boll weevil. Erratic control was reported from Texas. When bollworms are a problem, DDT should be added in

amounts sufficient to apply 0.5 to 1.0 pound per acre. For thrips and cotton fleahopper control it should be used at 0.2 pound per acre, and for cotton leafworm control at 0.3 pound. It is equally effective in a dust or spray against these pests.

See Hazards and Precautions in the Use of Insecticides, p. 5.

Malathion

This compound is reported to be less toxic to warm-blooded animals than several other phosphorus compounds. It is effective in the control of the desert spider mite, the cotton aphid, and leafhoppers at a dosage of 0.25 to 0.75 pound of the technical material per acre. It has given erratic results against the two-spotted spider mite.

Field experience with malathion has been limited. Special precautions should be exercised in its use until more is known about its toxicity to man and animals.

See Hazards and Precautions in the Use of Insecticides, p. 5.

Methyl Parathion (methyl ester of parathion)

This compound was widely tested in 1952 and 1953. It will control the boll weevil at dosages between 0.25 and 0.5 pound of the technical material per acre. Under heavy weevil populations and weevil migration this material may not have sufficient residual toxicity to give adequate protection under conditions of extremely high temperatures. Within this dosage range it is effective against the cotton aphid, the desert spider mite, and the cotton leafworm. It is not effective against the bollworm, the pink bollworm, or the two-spotted spider mite.

Methyl parathion is a dangerous poison. It is much more toxic to warm-blooded animals than most poisons used in cotton-insect control. Therefore, it should be handled with extreme caution and the directions prescribed by the manufacturers should be strictly followed.

See Hazards and Precautions in the Use of Insecticides, p. 5.

Ovotran (p-chlorophenyl p-chlorobenzenesulfonate)

This material will effectively control spider mites when applied at a rate of 2 to 3 pounds of the technical material per acre. Thorough treatment and contact of the mites is essential for good control. Its action is somewhat slower than that of Aramite. Where immediate "knock down" of mites is essential, the addition of parathion or TEPP to Ovotran should be considered.

Schradan (octamethyl pyrophosphoramide)

Schradan was translocated by cotton plants in laboratory tests when it was applied to soils in which the plants were growing. A single soil application at the rate of 4 to 8 pounds of the compound per acre caused the plants to remain toxic to cotton aphids and spider mites for several months. In laboratory and field tests spray application to foliage at the rate of 0.5 to 1 pound of schradan per acre gave aphid and mite protection for 2 to 4 weeks. Cotton seedlings grown from seed treated with 1 pound of schradan per 100 pounds of seed were toxic to aphids and mites for 6 weeks. Schradan is ineffective against the boll weevil, the bollworm, the pink bollworm, the cotton leafworm, the cotton flea-hopper, thrips, and a number of other cotton insects.

Preliminary tests have indicated that when schradan was used on cotton at 1 pound per acre, a residue of 6 to 8 p.p.m. was found in the raw cotton seed oil 40 days after application. This residue was initially eliminated into the soap stock in the refining process.

Schradan is a dangerous poison. It is much more toxic to warm-blooded animals than most poisons used in cotton-insect control. Therefore, it should be handled with extreme caution and the directions prescribed by the manufacturers should be strictly followed.

See Hazards and Precautions in the Use of Insecticides, p. 5.

Strobane

This material, which is a chlorinated mixture of alpha-pinene isomers having approximately 65 percent of chlorine, was considerably less effective than toxaphene against the boll weevil and the cotton leafworm in field-cage tests in 1952. The amounts of active ingredient per acre required to cause mortalities of 50 percent against the boll weevil were 1.05 and 2.05 pounds for toxaphene and Strobane, respectively; against the cotton leafworm, these amounts were 0.84 and 1.04 pounds.

In South Carolina Strobane gave effective control of the boll weevil at 2 pounds per acre in 1953, both in a dust and spray. In two tests, the addition of DDT to Strobane (1:4) increased its effectiveness against this insect over that of Strobane alone. In large-scale demonstrations in Georgia good results were obtained with dusts. Strobane did not control the cotton aphid or spider mites, although high populations of these pests did not develop after its use on cotton in South Carolina.

See Hazards and Precautions in the Use of Insecticides, p. 5.

Cultural Practices That Aid in the Control of Cotton Insects

Certain cultural practices reduce cotton losses from insect pests. They often reduce, and may eliminate, the need for insecticides and therefore should be encouraged. Several of these practices can be used by every cotton grower, whereas others are applicable only to certain areas and conditions. Besides following these practices, growers should continue to make careful observations for insects and apply insecticides when needed.

Planting

Reasonably early planting of all cotton during a short period within an area enables the crop to produce maximum growth and fruit before insects multiply and spread from field to field. Early planting also makes earlier stalk destruction possible.

Varieties

Varieties of cotton that bear prolifically, fruit early, and mature quickly may set a crop before the boll weevil and other insects become numerous. This is especially true when other cultural control practices are followed.

Soil Improvement

Fertilization, rotation of crops, and plowing under of green manure crops are good farm practices and should be encouraged.

Other Host Crops of Cotton Pests

Cotton fields should be located as far as is practicable from other host plants of cotton insects. Thrips breed in onions, potatoes, carrots, legumes, and some other crops. They later move in great numbers into adjacent or interplanted cotton. Garden webworms, variegated cutworms, stink bugs, and lygus bugs may migrate to cotton from alfalfa. The cotton fleahopper migrates to cotton from horsemint, croton, and other weeds.

Hibernation Areas

The boll weevil hibernates in well-drained, protected areas in and near cotton fields during the winter. Spider mites overwinter on low-growing plants in or near fields. Clean cultivation reduces weevil hibernation quarters. Small patches of weeds near fields, along turnrows

and fences, or around stumps and scattered weeds in cultivated fields or pastures can be destroyed at small cost. Such practices are more effective where the cotton acreages are in sizeable blocks than in small patches. General burning of ground cover in woods is not recommended.

Seed cotton scattered along roadsides as it is being hauled to the gin may result in the distribution and survival of the pink bollworm. Trucks, trailers, and other vehicles in which seed cotton is hauled should be both tight and covered to minimize this hazard.

Gin plant sanitation should be practiced to eliminate hibernating quarters of pink bollworms and boll weevils on such premises. In areas where pink bollworms occur, State and Federal quarantine regulations require that gin trash be burned, sterilized, run through a hammer mill, composted, or be given other approved treatment.

Early Stalk Destruction

The destruction or killing of cotton plants as early as possible before the first killing frost, either by mechanical or chemical methods, forces the boll weevil into starvation before it goes into winter quarters. Early stalk destruction, especially over community- or county-wide areas, has greatly reduced the boll weevil problem in the Lower Rio Grande Valley and other parts of Texas. The importance of this practice is also recognized in pink bollworm control in most areas. Plowing under the crop residue as deeply as possible after the stalks are cut will also reduce the pink bollworm survival. Modern mechanically-operated stalk cutters and shredders facilitate early stalk destruction and complete coverage of crop residues. The use of these machines should be encouraged as an aid in the control of the boll weevil and the pink bollworm.

Legumes in Relation to Cotton-Insect Control

Soil-building and soil-conserving leguminous crops are generally fundamental in a cotton-growing program. It is recognized that a number of insects attack legumes and then transfer to cotton, thereby increasing the cotton-insect problems. This situation may have a tendency to discourage the use of legumes but it should not, as insect pests may be successfully controlled on both legumes and cotton.

Chemical Defoliation as an Aid to Insect Control

Chemical defoliation of cotton aids in the control of many cotton insects. It usually checks the growth of the plants and accelerates the opening of mature bolls, thereby reducing the damage and the late seasonal buildup in the population of the pink bollworm and the boll

weevil which would otherwise remain to infest next year's crop. It also prevents or reduces damage to open cotton by heavy infestations of aphids, whiteflies, and the cotton leafworm.

Early defoliation permits quicker harvesting and better use of mechanical pickers. It also permits earlier destruction of the stalks, an important aid in the control of the pink bollworm and the boll weevil. However, if losses in yield and quality are to be avoided, the youngest bolls to make cotton should not be less than 30 to 35 days old at the time of defoliation.

Detailed guides for use of different defoliants, and rates and methods of application, will be found in the Basic Defoliation Guides, developed by the Defoliation Conference, and issued by the National Cotton Council of America, Memphis, Tenn. This report contains information concerning the influence of plant activity, stage of maturity, and effect of environment on efficiency of the process. The report gives details relative to the various needs and benefits. It explains how loss in yield and quality of products may be caused by improper timing of the applications.

These guides to the use of the defoliation process are based on broad ecological areas rather than on State boundaries. An individual should consult a local agricultural specialist, if he has any doubt concerning proper methods, time of application, or actual need for the defoliation.

Machines of no Value in Increasing Yields of Cotton

Bug-catching Machines

Bug-catching machines are not recommended as a means of controlling cotton insects.

Electronic Devices

No evidence has yet been discovered by any recognized research agency which would support claims of effectiveness of so-called electronic devices for the control of insects in the field. Such devices are not recommended.

Light Traps

Investigations during the last two years have shown that light traps are helpful in determining the time of emergence, abundance, and dispersal of the pink bollworm. However, they are not effective for control of the pink bollworm, and there is no evidence that light traps will control any cotton insect.

Production Mechanization in Cotton-Insect Control

More and more cotton is being cultivated with tractors, thereby making it possible for certain insecticides to be applied with the cultivating operations. Tractors have also made it possible for the cotton grower to use shredders, strippers, mechanical harvesters and larger and better plows, all of which help in the control of the pink bollworm and the boll weevil.

The flaming operation for weed control is of questionable value in insect control.

Mechanical cotton pickers appear to have no direct effect on insect control, except that they require chemical defoliation, which has definite value in insect control. However, cotton strippers do affect pink bollworm control, for the infested bolls are collected and transported to gins so that any pink bollworms in the seed or refuse may be more easily destroyed.

Cotton stalk shredders not only destroy certain insects, particularly the pink bollworm, but enable the cotton growers over wide areas to have the cotton stalks destroyed before frost, thereby stopping the development of late generations of this insect and the boll weevil.

Fumigation of mechanical cotton pickers and strippers moving from pink bollworm infested areas to noninfested areas is required by quarantine regulations.

Chemical Control of Cotton Insects

The principal insecticides and acaricides and the recommended rates of application for the control of various cotton pests are given in table 1.

Beet Armyworm (Laphygma exigua (Hbn.))

The beet armyworm attacks seedling cotton plants and older plants during the fruiting period in the western part of the Cotton Belt. Squares and blooms may be destroyed, and feeding on the bracts may cause bolls to shed. DDT at the rate of 1 to 1.5 pounds per acre is the most effective control. Toxaphene at 2 to 4 pounds per acre is also effective, but slower in action.

Boll Weevil (Anthonomus grandis Boh.)

Variations in the effectiveness of insecticides approved for control of the boll weevil have been observed not only in local areas, but during certain periods of time. The choice of insecticides will be determined by their effectiveness in the particular area where the insect is to be

Recommended Dosages for the Principal Insecticides and Miticides Used for the Control of Certain Cotton Pests

(Pounds per acre of technical material in a dust or emulsion spray)

Pesticide	Boll weevil	Bollworm	Cotton aphid	Cotton fleahopper	Cutworms	Fall armyworm	Grasshoppers	Lygus and other mirids	Cotton leafworm	Spider mites	Stink bugs	Pink bollworm	Thrips
Aldrin	0.25-0.75	--	--	0.20-0.25	--	0.25-0.5	0.10-0.25	0.25-0.75	--	--	--	--	0.08-0.15
Aramite	--	--	--	--	--	--	--	--	--	0.33-1.0	--	--	--
BHC (gamma)	0.30-0.45	--	0.3-0.6	0.1	--	0.4-0.6	0.3-0.5	0.30-0.45	--	--	0.5	--	0.1-0.2
Calcium arsenate ^{1/}	7-10	12-15	--	--	--	--	--	--	7-10	--	--	--	--
Chlordane	1.0-1.5	--	--	0.2	--	1.5-2.0	0.5-1.5	1.0-1.5	--	--	--	--	0.5-1.0
DDT	--	0.5-2.0	--	0.5	1-2	0.5-1.5	--	1.0-1.5	--	--	--	2-3	0.25-1.50
Demeton ^{2/}	--	--	0.125-0.40	--	--	--	--	--	--	0.125-0.4	--	--	--
Dieldrin	0.15-0.50	--	--	0.10-0.15	0.3-0.5	0.15-0.3	0.07-0.125	0.15-0.50	--	--	0.5	--	0.05-0.15
Endrin ^{2/}	0.2-0.5	0.2-0.5	--	0.1	--	--	--	0.2-0.5	0.2-0.5	--	--	--	0.08-0.15
Heptachlor	0.25-0.75	--	--	0.20-0.25	--	--	0.25-0.50	0.25-0.75	--	--	--	--	0.08-0.15
Nicotine ^{1/}	--	--	0.30-0.45	--	--	--	--	--	--	--	--	--	--
Parathion	--	--	0.1-0.5	--	--	--	--	--	0.125	0.10-0.4 ^{3/}	--	--	--
Sulfur ^{1/}	--	--	--	--	--	--	--	--	--	20-60 ^{3/}	--	--	--
TEPP (40%) ^{2/}	--	--	0.5 pint	--	--	--	--	--	--	--	--	--	--
Toxaphene	2-3	2-4	--	0.75-1.0	2-5	2-3	1.0-2.5	2-3	1.5-2.0	--	6.0	--	0.75-1.0

^{1/} Dust only.

^{2/} Spray only.

^{3/} Does not control all species.

controlled. Dosages of technical material that have controlled the boll weevil in one or more areas are as follows:

<u>Insecticide</u>	<u>Type of Application</u>	<u>Pounds per Acre</u>
Aldrin	Spray or dust	0.25 to 0.75
BHC (gamma isomer)	Spray or dust	0.30 to 0.45
Calcium arsenate	Dust	7 to 10
Chlordane	Spray or dust	1 to 1.50
Diieldrin	Spray or dust	0.15 to 0.50
Endrin	Spray	0.20 to 0.50
Heptachlor	Spray or dust	0.25 to 0.75
Toxaphene	Spray or dust	2 to 3

However, when these insecticides are used for boll weevil control, other insect problems have to be considered. Infestations of the cotton aphid, the bollworm, the tobacco budworm, and/or spider mites may develop when some of these insecticides are used alone. Because of the particular danger of the rapid buildup of the bollworm and the tobacco budworm, DDT should always be added to aldrin, BHC, chlordane, diieldrin, and heptachlor. (For rates see under the respective insecticides or pests.) Toxaphene, if properly timed, will control bollworms without DDT. However, if it is used alone late in the season, careful checks should be made at 3- to 5-day intervals. If their numbers are found to be increasing, DDT should be included in subsequent applications or should be applied alone.

Aphids may build up rapidly after the use of calcium arsenate or DDT, or DDT formulated with aldrin, chlordane, diieldrin, endrin, heptachlor, or toxaphene. Spider mites may build up rapidly after the use of the last six chemicals and BHC, either when used alone or with DDT. Careful checks should be made at 5- to 7-day intervals, and if these pests are found to be increasing appropriate control measures should be started at once. (See sections under cotton aphids and spider mites.)

Insecticides should be applied for boll weevil control when definite need is indicated. Except where early-season control is practiced, insecticides should be applied every 4 to 5 days until the infestation is brought under control. Fields should be inspected weekly thereafter and applications made when necessary.

Bollworm (Heliothis armigera (Hbn.)) and Tobacco Budworm (H. virescens (F.))

The bollworm and the tobacco budworm are the common bollworms attacking cotton. Several other species of lepidopterous larvae that sometimes also cause boll injury are discussed elsewhere in this report.

It is difficult to control bollworms, and their effective control depends on the thorough and timely use of properly formulated insecticides. Frequent field inspections to determine the presence of eggs and young larvae during the fruiting period and especially during the peak fruiting period of cotton are essential. It is too late for effective control after the larvae have entered the bolls.

Bollworms are controlled with DDT. For heavy infestations DDT should be applied at the rate of 1 to 1.5 pounds per acre in a dust or in a spray. (In the far west higher dosages may be needed.) It may be used in mixtures with other insecticides where other insects, as well as bollworms, require control. It is compatible with low-lime calcium arsenate but not with regular calcium arsenate. Bollworms usually are controlled where 0.5 pound or more of DDT per acre is applied with BHC, aldrin, chlordane; dieldrin, or heptachlor in the regular schedule for boll weevil control. Toxaphene at the rate of 2 to 4 pounds per acre usually controls the bollworm. It may be applied as a 20-percent dust. The addition of DDT to toxaphene spray is desirable and usually results in better bollworm control.

Calcium arsenate is less effective than DDT, toxaphene, or endrin. Endrin applied in a spray at a rate of 0.2 to 0.5 pound of the technical material per acre controls bollworms; however, the addition of DDT to the minimum dosage will usually give more effective bollworm control.

In areas where spider mites are a problem, dusts containing organic insecticides used for the control of bollworms should include at least 40 percent of sulfur or an appropriate amount of some other suitable miticide.

Cotton Aphid (Aphis gossypii Glov.)

Heavy infestations of the cotton aphid may occur on cotton after the use of certain insecticides, and also on seedling cotton where no insecticides have been applied. Aphid buildup in the boll weevil areas will usually be prevented by the following treatments:

1. A dust or spray containing BHC and DDT applied at the rate of 0.3 pound of the gamma isomer, and 0.5 pound of DDT per acre in every application
2. A dust containing 3 percent of the gamma isomer of BHC, 5 percent of DDT, and 40 percent of sulfur applied at the rate of 10 to 12 pounds per acre alternately with calcium arsenate.
3. Nicotine 2 percent in regular calcium arsenate dust applied at the rate of 10 to 12 pounds per acre alternated with calcium arsenate alone.

4. Parathion 1 percent in low-lime calcium arsenate dust; or when added at the rate of 0.1 pound per acre to dusts or sprays of the following insecticides when these are formulated with DDT and used at the recommended rate for boll weevil control: Aldrin, dieldrin, heptachlor, and toxaphene.
5. Toxaphene at the rate of 2 to 3 pounds per acre in every application (where toxaphene is not formulated with DDT), either in a dust or a spray.

When infestations of the cotton aphid are heavy and the need for rapid kill is indicated, the following treatments are usually effective:

1. BHC applied in either a dust or spray to give 0.3 to 0.6 pound of the gamma isomer, or an equivalent amount of lindane per acre.
2. Parathion applied in either a dust or spray at a rate of 0.1 to 0.25 pound of technical material per acre.
3. Nicotine 3 percent in hydrated lime dust applied at the rate of 10 to 15 pounds per acre.
4. TEPP applied in a spray at the rate of 0.5 pint of the 40-percent concentrate, or its equivalent, per acre. The effectiveness of this material is of short duration.
5. Demeton applied in a spray at a rate of 0.125 to 0.4 pound per acre

Cotton Fleahopper (Psallus seriatus (Reut.))

The cotton fleahopper can be controlled with the following dusts applied at the rate of 10 pounds per acre: DDT 5, toxaphene 10, dieldrin 1.5, aldrin 2.5, heptachlor 2.5, BHC gamma isomer 1, and chlordane 2 percent. When spider mites are likely to be a problem, 40 percent or more of sulfur or an appropriate amount of some other suitable miticide should be added to organic insecticide formulations.

The following materials applied as low-gallonage sprays at the rates indicated per acre will give good control of the cotton fleahopper: DDT 0.5, toxaphene 0.75 to 1, toxaphene 0.5 plus DDT 0.25, dieldrin 0.1, aldrin 0.2, heptachlor 0.2, chlordane 0.2, gamma BHC 0.1, or endrin 0.1 pound.

Cotton Leaf Perforator (Bucculatrix thurberiella Busck)

The cotton leaf perforator is at times a serious defoliator of cotton in certain areas of southern California and Arizona. It is controlled with DDT dust or spray at the rate of 1.5 to 3 pounds per acre or with a dust containing 15 percent of toxaphene and 5 percent of DDT at 15 to 25 pounds per acre. Endrin spray applied at the rate of 0.125 pound per acre is also effective.

Cotton Leafworm (Alabama argillacea (Hbn.))

The cotton leafworm has been controlled successfully for many years with calcium arsenate, paris green, or lead arsenate. Although effective control has been obtained with a dust containing 20 percent of toxaphene applied at 10 pounds per acre or at 1.5 pounds per acre applied in a spray, recent investigations indicate that higher dosages may now be required. Toxaphene-DDT spray applied at the rate of 1 pound of toxaphene and 0.5 pound of DDT, or parathion at 0.125 pound in a dust or spray, or endrin spray at 0.2 to 0.5 pound per acre has also been effective. Dusts containing 3 percent of the gamma isomer of BHC alone or plus 5 percent of DDT applied at 10 pounds per acre and BHC and DDT spray formulations applied at the rate of 0.3 pound of the gamma isomer and 0.5 pound of DDT per acre have given effective control when used in a regular program for the control of other cotton insects.

Cutworms

A number of species of cutworms, including the following, may develop in weeds or crops, especially legumes:

Black cutworm (Agrotis ypsilon (Rott.))

Pale-sided cutworm (Agrotis malefida Guen.)

Variegated cutworm (Peridroma margaritosa (Haw.))

Granulate cutworm (Feltia subterranea (F.))

Army cutworm (Chorizagrotis auxiliaris (Grote))

Cutworms migrate to adjacent cotton or attack cotton planted on land previously in weeds or legumes.

Recommended control measures include thorough seed-bed preparation, elimination of weed host plants, and the use of insecticides. In western areas, irrigation of the fields forces the subterranean forms to the surface, where they may be treated with insecticides or destroyed by natural factors. The need for insecticide control may be eliminated between the time an infested area is plowed under and the subsequent cotton crop is seeded.

Toxaphene and toxaphene-DDT (2:1) sprays applied at 2 to 4 pounds, DDT sprays at 1 to 2 pounds, or dieldrin at 0.3 to 0.5 pound per acre are effective. A dust containing 20 percent of toxaphene or 10 percent of DDT applied at 10 to 25 pounds per acre will give satisfactory control. Poison baits containing paris green, cryolite, sodium fluosilicate, toxaphene, or DDT have been satisfactory. A bait containing 80 percent of bran, 11 percent of oil, and 8 to 9 percent of a 25-percent DDT emulsifiable concentrate applied at the rate of 15 to 20 pounds per acre has given effective control.

Fall Armyworm (Laphygma frugiperda (J. E. Smith))

The fall armyworm occasionally occurs in sufficient numbers to damage cotton. The following dusts applied at the rate of 10 to 15 pounds per acre have given good control: Toxaphene 20 percent, sufficient BHC to give 3 percent of the gamma isomer plus 5 percent of DDT, or DDT 10 percent. Chlordane 10 percent at 15 to 20 pounds per acre is also effective. Toxaphene applied at 2 to 2.5 pounds or DDT at 0.5 to 1 pound per acre in sprays have given good control. Other insecticides that have been effective when applied in sprays are dieldrin 0.15 to 0.3 pound, BHC containing 0.4 to 0.6 pound of the gamma isomer, and aldrin 0.25 to 0.5 pound per acre. The results obtained from these materials have varied in different States; therefore, local recommendations are advisable. (Also see Bollworms, page 29.)

False Wireworms (Blapstinus and Ulus spp.)

Larvae of darkling ground beetles belonging to these genera occasionally affect the stand of young cotton in the western areas. They may be controlled by slurring 2 ounces of lindane onto each 100 pounds of planting seed. Adults on young cotton plants may be controlled with 5-percent chlordane dust at the rate of 20 pounds per acre, or with toxaphene, DDT, or a toxaphene-DDT (2:1) mixture applied in sprays at the rate of 1 to 2 pounds per acre.

Field Cricket (Acheta assimilis F.)

The field cricket occasionally feeds on cotton bolls and seedling plants in the Imperial Valley of California and in Arizona. During periods of drought late in the season the crickets may feed on the seed of open bolls, especially in the Delta sections of Arkansas, Louisiana, and Mississippi. This feeding is usually done at night by crickets that hide during the day in deep cracks in the soil. Crickets may be controlled with a 10-percent DDT or 5-percent chlordane dust applied at the rate of 20 to 25 pounds per acre. A dust containing sufficient BHC to give 2 percent of the gamma isomer plus 5 percent of DDT plus 40 percent of sulfur applied at the rate of 15 to 20 pounds per acre is also effective.

Garden Webworm (Loxostege similalis (Guen.))

The garden webworm may be controlled on cotton with dusts containing 5 percent of DDT plus sufficient BHC to give 3 percent of the gamma isomer, 20 percent of toxaphene, 1 percent of parathion, or 10 percent of DDT when applied at the rate of 15 pounds per acre. Good control of this insect may also be obtained with toxaphene, toxaphene plus DDT, DDT, heptachlor, and dieldrin sprays. DDT has given better control in sprays than in dusts and is generally less effective than the other materials.

Grasshoppers

A number of species of grasshoppers including the following sometimes attack cotton:

Differential grasshopper (Melanoplus differentialis (Thos.))

Lesser migratory grasshopper (M. mexicanus (Sauss.))

Red-legged grasshopper (M. femur-rubrum (Deg.))

Two-striped grasshopper (M. bivittatus (Say))

American grasshopper (Schistocerca americana (Drury))

The adults of the American grasshopper hibernate and deposit their eggs in the fields, but most other species overwinter in eggs in untilled soil, in fence rows, sod waterways, around stumps, and in other similar locations. The species overwintering in the egg stage can best be controlled with early treatment of hatching beds before the grasshoppers migrate into the fields. Sprays or dusts containing aldrin, chlordane, heptachlor, dieldrin, toxaphene, or BHC have largely replaced poison baits for grasshopper control in many areas. This is particularly true where grasshoppers must be controlled on lush or dense vegetation.

BHC sprays and dusts usually kill the grasshoppers in a few hours, but results have been erratic and residual effectiveness is limited to 1 to 2 days. Aldrin, chlordane, dieldrin, and toxaphene are very effective but slower in their action. However, they remain residually effective for several weeks depending on environmental conditions.

Dosages of technical material suggested to control grasshoppers come within the following ranges;

	<u>Pounds per Acre</u>
Aldrin	0.10 to 0.25
BHC, gamma isomer	0.30 to 0.50
Chlordane	0.50 to 1.50
Dieldrin	0.07 to 0.125
Heptachlor	0.25 to 0.50
Toxaphene.....	1.00 to 2.50

The lowest dosages are effective against newly hatched to half-grown grasshoppers. The dosage should be increased as the grasshoppers mature or when the materials are applied on partly defoliated plants or on plants unpalatable to the insects.

Baits made according to State and Federal recommendations still have a place in grasshopper control, particularly in sparse vegetation.

Lygus Bugs and Other Mirids

Several species of lygus bugs and other mirids including the following are often serious pests of cotton:

Tarnished plant bug (Lygus lineolaris (P. de B.))
Other lygus bugs (L. hesperus Knight and L. elisus Van D.)
Rapid plant bug (Adelphocoris rapidus (Say))
Superb plant bug (A. superbus (Uhl.))
Ragweed plant bug (Chlamydatus associatus (Uhl.))
Other mirids (Creontiades debilis (Van D.), C. femoralis (Van D.), and Neurocolpus nubilus (Say))

These insects cause damage to squares and small bolls of cotton and constitute a major problem, particularly in the irrigated regions of the West. DDT at the rate of 1 to 1.5 pounds per acre is widely used for the control of these insects. The other organic insecticides recommended for boll weevil and bollworm control are also effective against these bugs. In the Far West toxaphene at 3 pounds per acre is sometimes used.

Pink Bollworm (Pectinophora gossypiella (Saund.))

Survival and spread of the pink bollworm over Texas and into parts of Louisiana and Oklahoma were favored by weather conditions in 1951 and 1952. Heavy losses from this pest were experienced in southern Texas in 1952. Hibernation tests carried out during the winter of 1952-53 in northern and western Texas and in southwestern Oklahoma proved that large numbers of pink bollworms successfully overwintered in those areas during that mild winter. The thorough early destruction of stalks in the extreme southern portion of Texas resulted in a low carry-over during the winter of 1952-53. However, in parts of the Coastal Bend area where stalk cleanup was delayed, heavy infestations appeared in blooms. The drought coupled with late irrigation of some fields led to a concentration of infestation in late cotton and considerable loss. In central Texas infestation was generally slightly above that of

1952, but damage was not appreciable. At the end of the 1953 season, inspection by various methods showed distribution as indicated on map.

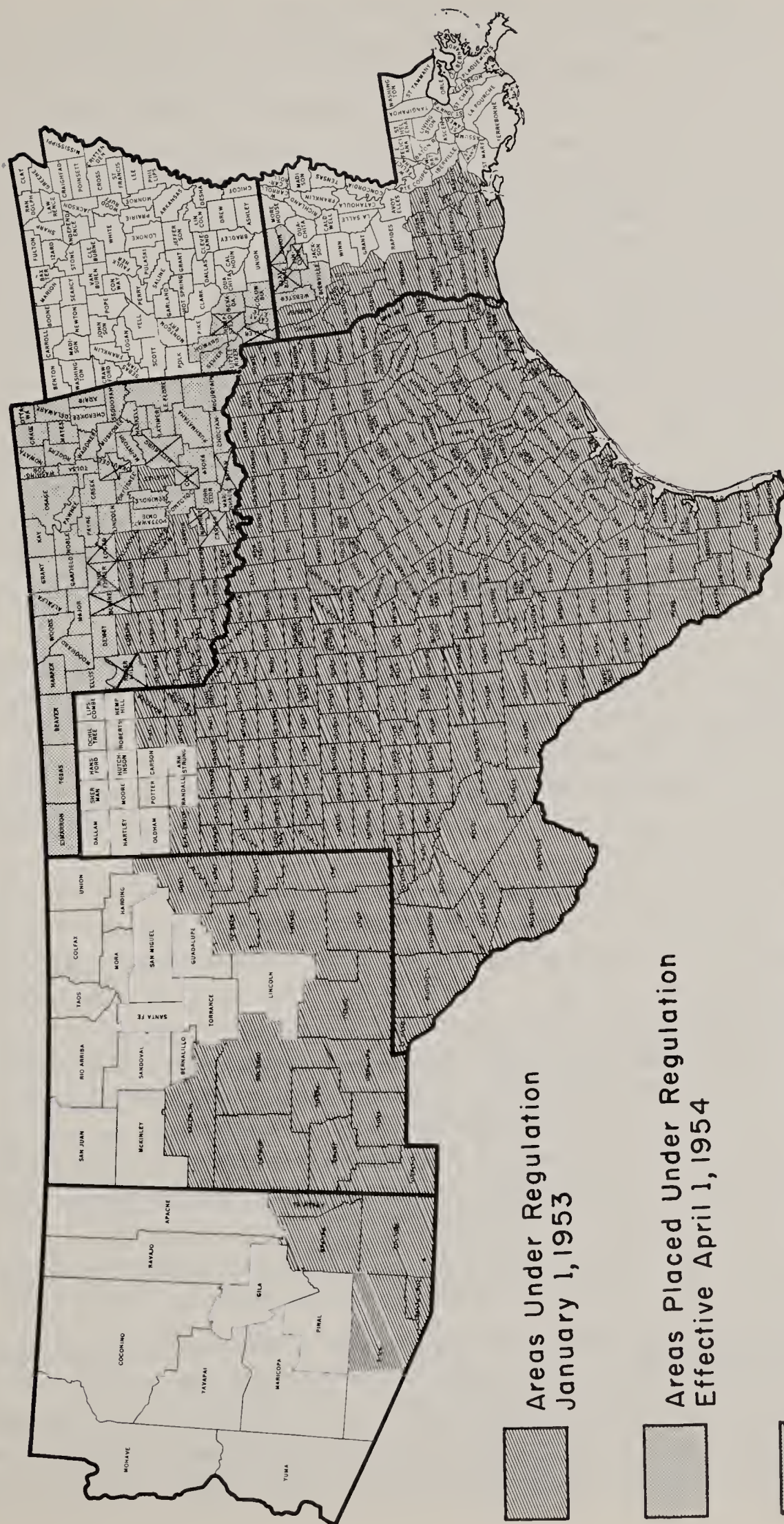
Pink bollworm infestations can usually be greatly reduced by cultural methods which entail little expense. This bollworm is the only major cotton insect that passes the winter in the larval stage primarily in the seed--in either seed cotton taken from the field or in the old bolls and locks left in the field after harvest. Quarantine requirements enforced by the States and the Federal Government insure that the seed, lint cotton, and gin trash receive treatments to kill pink bollworms they contain. It is recommended that these requirements be rigidly observed in order to prevent a local buildup and spread of the insect to new areas. This leaves only the worms in the crop residue in the field to carry over infestation to the next crop. Fortunately, the same cultural practices recommended for controlling the pink bollworm will, to a large extent, control the boll weevil. Expensive applications of insecticides can thus be avoided and a greater profit result.

Plans for controlling the pink bollworm should be made well in advance and aimed at the production of a quick early crop and a prompt thorough destruction of crop residue. Measures that will accomplish this objective follow:

1. Plant as early in the season as is considered safe for your locality, and use seeds of an early-maturing variety that have been culled, treated with a fungicide, and tested for germination.
2. Leave as thick a stand as has been recommended for your section and type of soil.
3. Use insecticides to control early cotton insects such as thrips, aphids, the cotton fleahopper, the boll weevil, and cutworms, which may retard the growth and fruiting of the young plants or make replanting necessary.
4. Withhold late irrigations and use defoliants to hasten the opening of the bolls.

The destruction of overwintering worms in the bolls and locks of cotton left in the field is the most important step in control of the pest. As many bolls as possible should be removed by snapping, mechanical stripping, or by heavy pasturing. Mechanical stripping has proved to be an efficient means of removing bolls where the cotton is not too rank in growth. Where these methods cannot be used and the infestation is known to be heavy, cutting, raking, and burning of the crop debris is justified.

Destroy stalks immediately after the harvest with shredders if possible. Shredders kill about half of the pink bollworms by mechanical action and spread the residue evenly on the ground, so that it can be



Areas Under Regulation January 1, 1953

Areas Placed Under Regulation Effective April 1, 1954

Counties Outside of Regulated Area of January 1, 1953 found infested first time during 1953 Crop season

more thoroughly covered in the plowing operation. In hot, dry weather most of the pink bollworms will be killed if this residue is exposed to the sun for a week after shredding. In a large part of southern, central, and eastern Texas the cotton can be harvested before frost and late build-up of pink bollworms and boll weevils prevented. Many farmers in the southern parts of Texas and Louisiana can complete the harvest of the crop and destroy the stalks several weeks before the legal deadline date established by State regulations. Where excessive rains late in the season prevent early stalk destruction, application of dessicants will stop plant growth and a late seasonal buildup of pink bollworms and boll weevils, and will permit salvaging of part of the crop. This practice is not so effective as early stalk destruction and is recommended only as an emergency measure.

After the stalks have been destroyed, the residue should be plowed under as deeply as possible. Pink bollworm survival is highest in bolls on the soil surface and is six times higher in bolls buried only 2 inches deep than in bolls buried 6 inches deep. All sprout and seedling cotton developing after plowing should be destroyed before fruiting to create a host-free period between crops.

In the colder arid areas stalks should be left standing during the winter months, since the highest mortality in such areas occurs in bolls on the standing stalks. In any area where water is available, fields should be winter-irrigated.

The recommended measures are most effective when carried out on a community- or county-wide basis and will pay large dividends in savings on insecticides.

Where heavy infestations develop, crop losses from the pink bollworm can be reduced by the proper use of insecticides. The most effective material for its control is DDT, which should be applied at weekly intervals either in a dust or spray at the rate of 2 to 3 pounds per acre. Where other insects as well as the pink bollworm require control, DDT can be mixed with other organic insecticides or with low-lime calcium arsenate. When the interval of application is reduced to 4 or 5 days for control of other insects, the quantity of DDT may be reduced accordingly, or to the rate of 1 to 1.5 pounds per acre in combination with the other insecticides. Thorough coverage of the cotton plants with the insecticide is essential in the control of the pink bollworm.

The following methods of inspection should be used in determining when to start insecticide treatment for pink bollworm control:

Bloom Inspection. -- Early in the season make infestation counts when there is at least 1 bloom for every 4 or 5 plants but not more than 1 bloom for every 2 plants. Beginning at the margin, walk diagonally across the field and inspect several hundred blooms for those rosetted (blooms with the petals webbed together at the tips). Check for the

number of blooms infested on a percentage basis. When from 5 to 10 percent of the blooms are infested, insecticide treatment should be delayed until the first bolls are about 20 days old. When more than 10 percent are infested, insecticide treatments should be started immediately.

Boll Inspection. --Walk diagonally across the field and collect at random 100 hard green bolls from the bottom of the plant. Examine each boll as follows: Remove the bracts by cutting off a small layer from the base of the boll; cut each section or carpel midway between the sutures so that each lock can be removed intact; examine the inside of the boll wall for characteristic tunnels or mines made by the young larvae. The number of bolls found infested represents the percentage infestation. When 10 percent or more of the bolls are infested, insecticide treatment should be started immediately.

In all cases, insecticide treatment must be continued until most of the bolls are open.

Seed-Corn Maggot (Hylemya cilicrura (Rond.))

The seed-corn maggot may seriously affect the stand of cotton, particularly when planting closely follows the turning under of a green manure crop or other heavy growth. This insect may be controlled with 1 to 2 ounces of lindane applied as a wettable powder onto each 100 pounds of planting seed. Seed should be treated immediately before planting.

Spider Mites

The following spider mites are known to attack cotton in the United States:

Strawberry (Atlantic) spider mite (Tetranychus atlanticus McG.)
Two-spotted spider mite (T. bimaculatus Harvey)
Four-spotted spider mite (T. canadensis (McG.))
Desert spider mite (T. desertorum Banks)
Pacific spider mite (T. pacificus McG.)
Schoene spider mite (T. schoenei McG.)
Tumid spider mite (T. tumidus Banks)
Brown wheat mite (Petrobia latens (Mueller))

These species differ in their effect on the cotton plant and in their reaction to miticides. Accurate identification of the species is essential. The use of organic insecticides for cotton-insect control has been a factor in the changing importance of these pests.

The two-spotted spider mite is the most difficult species to control on cotton. It occurs as the green form in many areas and as the carmine

subspecies (T. b. multisetis (McG.)) in the South and in southern California. Both forms can be controlled with demeton at 0.125 to 0.4, Aramite at 1, and Ovotran at 2 to 3 pounds per acre. Parathion at 0.2 to 0.4 pound per acre is also effective in some localities.

The Pacific spider mite is restricted to the Pacific coast, where it has been a major pest of cotton. Sulfur at 60, demeton at 0.25 to 0.40, Ovotran at 2 to 3, and Aramite at 1 pound per acre give effective control of this species. The other organic phosphorous compounds are not satisfactory.

The strawberry (Atlantic) spider mite first attacks the lower leaves of the plant and causes severe defoliation. Demeton at 0.25 to 0.40, Ovotran at 2 to 3, Aramite at 1, and sulfur at 20 to 25 pounds per acre give effective control.

The desert spider mite and the tumid spider mite are controlled with sulfur at 20 to 25, parathion at 0.1 to 0.25, and Aramite at 0.3 to 0.75 pound per acre.

The brown wheat mite may attack seedling cotton in the far west. Parathion at 0.3 pound and sulfur at the rate of 25 to 30 pounds per acre during warm weather will control this species.

In some areas where mites are a problem, they may be effectively controlled by including a suitable miticide at a comparatively low rate in all applications of cotton insecticides. For control of some species and supression of others, at least 40 percent of sulfur may be incorporated in all dust applications. Elemental sulfur cannot be incorporated in sprays applied at low gallonage. Other miticides may be substituted.

Sulfur dust is most effective when finely ground and when applied at temperatures above 90° F. Thorough coverage is essential for effective results in the use of miticides.

Stink Bugs

The following stink bugs are sometimes serious pests of cotton:

Conchuela (Chlorochroa ligata (Say))

Say stink bug (C. sayi Stal.)

Southern green stink bug (Nezara viridula (L.))

Green stink bug (Acrosternum hilare (Say))

Brown cotton bug (Euschistus impictiventris Stal.)

Brown stink bug (E. servus (Say))

(Also E. variolarius (P. de B.), tristigmus (Say), and conspersus Uhl.)

Red-shouldered plant bug (Thyanta custator (Fab.))

(Also T. rugulosa (Say), brevis Van D., and punctiventris Van D.)

The importance of these pests and the species involved varies from year to year and from area to area. The damage they cause is confined principally to the bolls and results in reduced yields and lower quality of both lint and seed. Dieldrin and gamma BHC at 0.5 pound per acre give control of these stink bugs. Toxaphene at 6 pounds per acre gives fair to good control and is sometimes preferred where a bee hazard is involved.

A dust containing sufficient BHC to give 2 percent of the gamma isomer, 5 percent of DDT, and 50 percent of sulfur applied at the rate of 15 to 30 pounds per acre also gives control of stink bugs, lygus bugs, bollworms, and cotton aphids, and is widely used for the control of these pests in the Western areas.

Thrips

Thrips often cause injury to cotton seedlings, especially in areas where vegetables, legumes, and small grains are grown extensively. The following species have been reported as causing this injury:

Tobacco thrips (Frankliniella fusca (Hinds))

Flower thrips (F. tritici (Fitch))

(Also F. runneri (Morg.) and exigua Hood)

Onion thrips (Thrips tabaci Lind.)

(Also Sericothrips variabilis (Beach))

In some areas cotton plants usually recover, so that controls are not recommended unless the stand is threatened. In other areas, to the contrary, thrips damage is more severe than is generally realized. Although thrips usually injure seedling cotton, damaging infestations sometimes occur on older cotton in certain areas.

The destruction of leaf tissue by thrips, and the subsequent slowing of plant growth, may make the seedlings more susceptible to injury by diseases. Injury by thrips alone, or the combined injury of thrips and disease, may reduce or even destroy stands of young plants. A heavy infestation may retard plant growth and delay fruiting and crop maturity.

A number of insecticides give satisfactory control of thrips and are recommended when the situation warrants their use. Toxaphene at 0.75 to 1 pound per acre in either dusts or sprays gives effective control. A dust or spray consisting of 0.15 pound of the gamma isomer of BHC plus 0.25 pound of DDT per acre is also effective.

The following insecticides and dosages applied in dusts or sprays likewise give effective thrips control: Aldrin, endrin, and heptachlor 0.08 to 0.15 pound; and dieldrin, 0.05 to 0.15 pound per acre.

Other insecticides that give satisfactory control either in a spray or a dust are chlordane at 0.5 to 1 pound, BHC at 0.1 to 0.2 pound of

the gamma isomer, and DDT at 0.25 to 1.5 pounds per acre. DDT has not given satisfactory control at temperatures above 90° F. Sprays are more effective than dusts on seedling cotton. When applications are made by airplane, the dosages mentioned above should be increased by at least 50 percent.

Some of the organic phosphorous compounds are effective against thrips, but are not generally recommended.

The bean thrips (Hercothrips fasciatus (Perg.)) is a common mid-season pest of cotton in parts of California. DDT at 1 pound or toxaphene at 2 to 3 pounds per acre gives satisfactory control when applied in either sprays or dusts.

White-fringed Beetles (Graphognathus leucoloma (Boh.), peregrinus (Buch.), and minor (Buch.))

White-fringed beetles are pests of cotton and many other farm crops. They are present in limited areas of Alabama, Florida, Georgia, Louisiana, Mississippi, North Carolina, South Carolina, and Tennessee. The larvae feed on the roots of young cotton plants. These insects can be controlled by the use of good cultural practices and insecticides. Recommended cultural practices include the following:

1. Plant oats or other small grains in heavily infested areas.
2. Restrict planting of summer legumes, such as peanuts, soybeans, and velvetbeans, or other host plants of the adult beetles to not more than one-fourth of the total crop land. Do not plant these crops on the same land more than once in 3 or 4 years.
3. Do not intercrop corn with peanuts, soybeans, crotalaria, or velvetbeans. Prevent the growth of broad-leaved weeds, such as cocklebur and sicklepod.
4. Improve poorer soils by turning under winter cover crops.

DDT is effective against white-fringed beetle larvae. Apply 50-percent DDT at the rate of 20 pounds, or 25-percent DDT at 40 pounds per acre, evenly to the soil surface in a dust, spray, or mixture with sand, and thoroughly mix it into the upper 3 to 4 inches of soil. This treatment will give control of larvae for at least 5 years. DDT may also be used in the drill before planting. Use 50-percent DDT at 5 to 10 pounds or 25-percent DDT at 10 to 20 pounds per acre, mixed with sand. Apply by hand or with a fertilizer distributor, at or slightly below the depth of seed planting. DDT may be applied with a fertilizer.

Either toxaphene or BHC-DDT mixture applied on cotton foliage to combat other cotton insects leaves a residue in the soil that aids in the

control of these beetles. These insecticides should be used for the control of those cotton insects for which they are recommended in beetle-infested areas.

White-lined Sphinx (Celerio lineata (F.))

The white-lined sphinx occasionally occurs in uncultivated areas in large numbers and migrates to cotton fields. They may be controlled on cotton with DDT at 1 to 1.5 pounds or with toxaphene at 2 to 3 pounds per acre applied in a dust or spray. Migrations may be stopped by barrier strips of 10-percent DDT or 20-percent toxaphene.

Whiteflies (Trialeurodes abutilonea (Hald.)) and the Greenhouse Whitefly (T. vaporariorum Westw.)

Whiteflies are usually kept in check by parasites and diseases, but occasionally may be serious late in the season. Parathion at 0.125 to 0.5 pound per acre is effective against these insects, but repeated applications may be necessary for control.

Wireworms

Several species of wireworms are associated with cotton. Perhaps most noticeable damage is caused by the sand wireworm (Horistonotus uhlerii Horn.) in South Carolina, Louisiana, and Arkansas. Adults of the tobacco wireworm (spotted click beetle) (Conoderus vespertinus (F.)), are frequently found on the cotton plant, but the amount of damage the larvae cause to cotton is not known. Wireworms together with false wireworms and the seed-corn maggot sometimes prevent the establishment of a stand of cotton. To control these insects, the seed should be treated with 1 to 2 ounces of lindane per 100 pounds in a slurry.

Approved crop-rotation practices, increased soil fertility, and added humus help to reduce damage to cotton caused by the sand wireworm. Aldrin, chlordane, dieldrin, heptachlor, DDT, and BHC have shown promise in the control of this and other wireworms on other crops. Additional research on the control of wireworms attacking cotton is needed.

Yellow-Striped Armyworm (Prodenia ornithogalli Guen.), and the Western Yellow-Striped Armyworm (P. praefica Grote)

These insects may at times cause considerable damage to cotton. The yellow-striped armyworm has proved to be the most difficult of all the "bollworms" to kill with organic insecticides. EPN at 0.3 pound per acre applied in an emulsion spray was superior to any of the chlorinated hydrocarbons. However, when used in the early stages of worm development, toxaphene at 2.5 pounds, DDT at 1 pound, and dieldrin at 0.3 pound per acre in an emulsion spray gave fair control. Dieldrin in a 3-percent

dust and toxaphene in a 20-percent dust applied at the rate of 15 pounds per acre also gave good kills of a mixed population of large and small yellow-striped armyworms.

The western yellow-striped armyworm, which attacks cotton in California, is easily controlled with DDT applied in a dust or spray at 1 to 1.5 pounds per acre when these insects are on cotton. Migrations from surrounding crops may be stopped by barriers of 10-percent DDT or 20-percent toxaphene at the rate of 2 to 4 pounds per 100 feet.

Miscellaneous Insects

The cabbage looper (Trichoplusia ni (Hbn.)) and related species occasionally cause damage to cotton in localized areas. A dust containing 20 percent of toxaphene applied at the rate of 10 to 15 pounds per acre, or sprays containing toxaphene at 2 to 3 pounds or endrin at 0.25 to 0.50 pound per acre are effective.

The corn silk beetle (Luperodes brunneus (Crotch)) has been reported as a pest of cotton in localized areas in several States but little is known about it.

Cotton root aphids: The species of root aphids known to attack cotton are the corn root aphid (Anuraphis maidi-radicis (Forbes)), and Trifidaphis phaseoli (Pass.), and Rhopalosiphum subterraneum Mason. So far as is known, injury by root aphids to cotton is confined to the eastern seaboard. Several species of ants are known to be associated with root aphids, the principal one being the cornfield ant (Lasius alienus americanus Emery). Chemical control of root aphids has been directed at the control of this ant. Some of the new materials are known to be effective as soil insecticides, and it is suggested that they be tested against root aphids attacking cotton. Root aphids injure cotton chiefly in the seedling stage. Since cotton in this stage often shows signs of injury without any evidence of insects being present, it is suggested that careful examinations of the underground portions be made to determine the possibility of root aphid attack. Ant mounds at the base of seedling plants indicate the presence of root aphids.

The cotton square borer (Strymon melinus (Hbn.)) occurs throughout the Cotton Belt, but rarely causes economic damage. The injury this insect causes to squares is often attributed to the bollworm.

The cotton stainer (Dysdercus suturellus (H.-S.)) is found within the United States in Florida only. However, probably owing to mistaken identity, the literature also records it from Alabama, Georgia, and South Carolina. No work on control has been formally reported in recent years, but observations indicate that dusts containing 10 percent of toxaphene or sufficient BHC to give 1 percent of the gamma isomer will control insects of this genus. Indications are that DDT may also be effective.

The cotton stem moth (Platyedra vilella Zell.), a close relative of the pink bollworm, was first discovered in the United States in 1951, when larvae feeding in hollyhock seeds at Mineola, Long Island, N.Y., were collected by J. H. Mahaney, and determined by H. W. Capps of the Bureau of Entomology and Plant Quarantine. It is recorded as a pest of cotton in Iran, Iraq, Morocco, Transcaucasia, Turkestan, and U.S.S.R., and as feeding on hollyhock and other malvaceous plants in England, France, and Central and Southern Europe. Collections made in 1953 extended its known distribution in this country to a large part of Long Island and to limited areas in Connecticut and Massachusetts. Although this species has not been found on cotton in the United States, it is mentioned here because of the desirability of keeping on the lookout for it on cotton, hollyhock, and other malvaceous plants.

The cowpea aphid (Aphis medicaginis Koch) is common on very young cotton, especially on the cotyledonous leaves. Cotton is not believed to be a true host of this species, and the insect will not complete a life cycle on the cotton seedling.

The cowpea curculio (Chalcodermus aeneus Boh.) sometimes causes damage to seedling cotton.

Flea beetles. --The pale-striped flea beetle (Systema blanda Melsh.), the elongate flea beetle (elongata (F.)), and frontalis (F.) sometimes cause serious damage to seedling cotton in some areas. They can be controlled with chlordane at the rate of 0.5 pound, with aldrin at 0.25 to 0.5 pound, with dieldrin at 0.25 to 0.33 pound, with DDT at 1 pound, or with toxaphene at 2 to 3 pounds per acre in dusts or sprays. Other species of flea beetles have been reported from cotton, but carefully annotated records regarding the injury they cause are lacking. When flea beetle injury to cotton is observed, collections should be submitted with a statement regarding the nature and extent of damage they cause, the locality, and the date of collection.

The grape colaspis (Colaspis flavida (Say)) is widespread and is often found on cotton near the base of squares and bolls where it feeds on the bracts surrounding them, causing a characteristic type of injury.

Several of the leaf rollers (Tortricidae) occasionally damage cotton. Platynota stultana (Wlsm.) and rostrana (Wlkr.) are the species most commonly recorded; however, flavadena Clem. and idaeusalis (Wlkr.) have also been reported as causing injury to cotton. These species are widely distributed and have many host plants.

The pink scavenger caterpillar (Pyroderces rileyi Wlsm.) is one of several insects which resembles the pink bollworm. The larva is primarily a scavenger in cotton bolls and corn husks where other causes have produced the initial injury. It is sometimes mistaken by laymen as the pink bollworm.

The salt-marsh caterpillar (Estigmene acrea (Drury)) can be controlled with toxaphene applied in either a dust or a spray at the rate of 3 pounds per acre, preferably when worms are small. If worms are large 4 to 5 pounds per acre is required. Dust or spray mixtures containing DDT plus toxaphene in a 1:3 ratio applied at rates of 4 to 6 pounds of toxicant per acre or endrin spray at 0.2 to 0.5 pound per acre are effective. When dusts are used they should contain at least 40 percent of sulfur.

The stalk borer (Papaipema nebris (Guen.)) is widely distributed east of the Rocky Mountains. It attacks many kinds of plants including cotton and is so destructive that one borer in a field may attract attention. They are most likely to be noted near the edges of the cotton fields. Clean cultivation and keeping down weed growth help to hold them in check. The use of stalk shredders early in the fall should reduce their numbers. Information is needed concerning the effectiveness of chemicals for the control of this insect.

Occasionally the yellow woollybear (Diacrisia virginica (F.)) and the hairy larvae of several other tiger moths (Arctiidae), including Callarctia phyllira (Drury), arge (Drury), and oithona Strk., cause serious damage to cotton. Information is needed in regard to their seasonal host plants, distribution, natural enemies, causes of serious outbreaks in cotton fields, life history, and control. Determinations by specialists should always be obtained.

Honey dew from aphids causes "gummy" lint when it falls on open cotton or on picked cotton on the ground or in trucks and trailers. Vehicles used for hauling cotton should not be parked under pecan, cottonwood, sycamore, or other trees from which honey dew may fall. Weeds on which aphid infestations may develop should not be allowed in the cotton fields.

Insects in or Among Cottonseed in Storage

Cottonseed rarely becomes infested with insects while in storage when proper precautions are followed. Cottonseed or seed cotton should be stored only in a bin or room thoroughly cleaned of all old cottonseed, grain, hay, or other similar products in which insects that attack stored products are likely to develop. Among the insects that cause damage to stored cottonseed or to cottonseed meal are the cigarette beetle (Lasioderma serricorne (F.)), the Mediterranean flour moth (Ephestia kuhniella Zell.), and the Indian-meal moth (Plodia interpunctella (Hbn.)). Cottonseed that is to be used for planting only may be dusted with toxaphene before being placed in storage. Seed so treated should not be crushed or used for feed.

Biological Control of Cotton Insects

Predators, parasites, and diseases play an important role in the control of insect pests of cotton. Full advantage should be taken of these natural enemies and the overall pest control program should include the maximum integration of natural, chemical, and cultural control. To reach this goal there is an urgent need for fundamental studies on the ecology of cotton insects and their enemies and the effect of chemical control upon their relationships. An integrated pest-control program is most likely to reach its greatest efficiency with the expansion of programs such as supervised control. Wherever possible, an attempt should be made to evaluate the role of beneficial insects in the fields being checked.

Among the important predaceous insects that are often of value in the control of injurious insect pests of cotton are several species of ladybird beetles, the flower bugs, the aphid lions (lacewing flies), assassin bugs, the big-eyed bug, praying mantids, ground beetles, larvae of syrphid flies, and certain wasps. Several species of spiders are also predaceous on various insect pests of cotton.

Parasites that are often effective in controlling certain cotton pests include several species of wasplike insects, ranging in size from extremely small ones that develop in aphids and in the eggs of other insects to those the size of some of our common wasps, and several species of tachina flies that resemble somewhat the common house fly.

Thus far the importation and colonization of insect parasites of the pink bollworm and the boll weevil have not proved effective. On the other hand, native predators and parasites are often highly effective on such pests as the bollworm, spider mites, lygus bugs, whiteflies, and the cotton aphid.

Six species of parasites of the pink bollworm were imported from India in 1953, but only five of them were reared in sufficient numbers in the laboratory for release in pink bollworm infested cotton fields in southern Texas during the growing season. The releases totaled 352,446 individuals, consisting of the following species: Bracon brevicornis Wesm., B. gelechiae Ashm., Apanteles sp., and two species of Chelonus. A survey of infested cotton fields in which the parasites were released and in fields in the immediate vicinity will be made in 1954 to determine if any of the species were successfully established in the area.

The release of the common ladybird beetles Hippodamia spp. has little, if any, practical value in the control of the pink bollworm or other insect pests of cotton. While they might destroy some eggs or immature stages of other pests, their attack is primarily directed toward aphids. However, these beetles occur so widely throughout the country that the few it might be practical to release would add little to the numbers developed locally when seasonal conditions permit their normal increase.

Cotton Insects in the Irrigated Areas of the Southwestern States

Cotton-insect problems in the irrigated Southwest vary somewhat from those in the remainder of the Cotton Belt because of differences in climate, cultural practices, and kinds of insects present.

The combination of alkalinity, intense sunlight, high temperatures (regularly over 100° F. and frequently exceeding 110° F.), low humidity, and in most areas an absence of precipitation during the growing season make the environment of the cotton plant and its pests quite different from that in the South. Furthermore, intermittent irrigations bring severe changes to the environment. The large size of most western ranches and fields complicates insect control in some ways and simplifies it in others. Such cultural practices as double cropping, extensive use of commercial fertilizers, mechanical picking, and one-variety districts also affect insect problems in the Southwest.

These factors in conjunction with local and general isolation give the Southwest a different insect complex. The boll weevil and the cotton leafworm are absent or are only local problems. Of all the cotton insects that occur in the area, the pink bollworm is considered to be the greatest potential threat to cotton production. Currently the most important pests are lygus bugs and related insects, the bollworm, stink bugs, aphids, and spider mites. Other pests of importance are the beet armyworm, darkling beetles, cutworms, the seed-corn maggot, thrips, the salt-marsh caterpillar, the cotton leaf perforator, and whiteflies.

In the Southwest insecticides are generally applied less frequently but in larger amounts--15 to 35 pounds per acre--than in other parts of the Cotton Belt, and the actual amount of toxicant per acre is slightly higher. Nearly all treatments except early applications are applied by aircraft. Predators and parasites of cotton insects in the Southwest seem to be particularly important, and every effort is being made to protect them and to utilize them to the fullest extent.

Cotton Insects in Puerto Rico in 1953

Puerto Rico was not represented at the Conference, but Dr. Luis F. Martorell of the Department of Entomology, Agricultural Experiment Station, University of Puerto Rico at Rio Piedras, submitted a brief report.

The pink bollworm infestation was very low in 1953. A light infestation of the cotton leafworm developed at Isabela in the early Autumn. The cotton aphid was recorded on cotton at Aguirre on the southern coast of the Island in October and November. "Spraying with BHC at the rate of 1/4 pound of gamma isomer per 100 gallons of water controlled effectively the (aphid) infestation with three sprayings at 15 day intervals. The BHC was applied simultaneously with the DDT applications, which were used for the control of the pink bollworm."

"The Agricultural Experiment Station recommends the use of DDT, for the control of the pink bollworm as follows: 4 to 6 pounds per acre of 50-percent wettable DDT in 100 to 150 gallons of water, spraying at 15 day intervals, giving a total of 7 to 8 sprayings, starting as soon as the first squares are observed in the field."

Cotton Insect Surveys

The importance of surveys to an overall cotton-insect control program has been clearly demonstrated during the last few years. Cotton-insect surveys conducted on a cooperative basis by State and Federal agencies in most of the major cotton-growing States have developed into a broad, up-to-date advisory service for the guidance of the farmer and others associated with cotton production, as well as the chemical industry, which serves the farmers by supplying insecticides. As a result of this survey work, farmers are forewarned of the insect situation and losses are materially reduced below what they would be without the information thus gained. The survey also helps to direct insecticides to areas where supplies are critically needed.

It is recommended that cotton-insect surveys be continued on a permanent basis, that they be expanded to include all cotton-producing States, and that the survey methods be standardized.

It is further recommended that the greatest possible use be made of fall, winter, and early-spring surveys as an index to the potential insect infestation of next season's crop.

Wherever possible, voluntary cooperators should be enlisted and trained to make field observations and records and to submit reports during the active season.

More people are being employed each year by business firms, individual farm operators, and others interested in cotton production to determine cotton insect populations. It is important that individuals employed by private interests to make surveys understand the control programs as well as how to make infestation counts. Therefore, State and Federal entomologists should assist in locating and training personnel that have at least some basic work in entomology to survey for private interests.

Surveys to detect the presence of major insect pests in areas where they have not previously been reported may provide information that can be used in restricting insect spread or in planning effective control programs. The survey methods may include (1) visual inspection, (2) traps using aromatic lures, (3) traps using lights, (4) mechanical devices such as gin trash machines, (5) examination of glass windows installed in air cleaners used as part of the ginning process, and (6) additional measures that are discussed, where they apply, under Methods for Making Uniform Surveys, p. 50.

Methods for Making Uniform Surveys

Boll Weevil

Survey records are made in a number of States to determine winter survival of the boll weevil. Counts are made in the fall soon after weevils have entered hibernation and again in the spring before they emerge from winter quarters. A standard sample is 2 square yards of surface woods trash taken from the edge of a field where cotton was grown during the season. At least five samples are taken from a location.

In the main boll weevil area, population counts are made on seedling cotton to determine the number of weevils entering cotton fields from hibernation quarters. The number per acre is figured by examining the seedling plants on 50 feet of row in each of five representative locations in the field. Additional counts are desirable in large fields.

Examinations for boll weevils are made weekly after the plants are squaring freely or have produced as many as three squares per plant. While walking diagonally across the field pick 100 squares. They should be one-third grown or larger, and an equal number should be picked from the top, middle, and lower branches of the plants. Squares from the ground or dried-up squares that are hanging on the plant should not be picked. The number of squares found to be punctured is the percentage of infestation.

An alternative method is to inspect about 25 squares in each of several locations distributed over the field. The number of sample counts will depend upon the size of the field and the surrounding environment. Accurate infestation records in large fields will require additional counts in different parts of the field. The percentage of infestation is determined by counting the punctured squares.

In both methods, all squares that have egg or feeding punctures should be counted as punctured squares.

Bollworm

Examinations for bollworm eggs on cotton should be started when most of the corn silks in the area begin to dry, or at the time bollworms usually appear. Examinations should be repeated every 5 days if possible thereafter until the crop has matured.

While walking diagonally across the field, examine 100 main-stem terminals (about 3 or 4 inches of the top of the plant) for eggs and worms. If eggs are found on the terminals and 4 or 5 small larvae in the small squares or on the tender top leaves, the infestation is sufficiently heavy to start treatment. Insecticides should be applied at 5-day intervals as long as necessary.

To determine injury, inspect 100 bolls and 100 squares while walking diagonally across the field and compute the percentage of injury for each. The boll-injury record is the most indicative of existing or occurring damage.

In an alternative method of estimating bollworm damage make observations while walking diagonally across a field. The degree of injury may be recorded as follows:

None, if no damage is observed.

Light, if only a few squares and bolls show injury.

Medium, if injured squares and bolls are readily noticeable over most of the field.

Heavy, if numerous injured squares and bolls are noticed over the field.

Cotton Aphid

To determine early-season aphid infestations, while walking diagonally across the field make observations or inspections of many plants. Degrees of infestation may be recorded as follows:

None, if none is observed.

Light, if a few aphids are found on an occasional plant.

Medium, if aphids are present on numerous plants and some of the leaves show a tendency to curl along the edges.

Heavy, if aphids are numerous on most of the plants and if the leaves show considerable crinkling and curling.

To determine aphid infestations on fruiting cotton, begin at the margin of the field and, while walking diagonally across it, examine 100 leaves successively from near the bottom, the middle, and the top of the plants. The degree of infestation, according to the average number of aphids estimated per leaf, may be recorded as follows:

None	0
Light	1 to 10
Medium	11 to 25
Heavy	26 or more

Cotton Fleahopper

Weekly inspections for the cotton fleahopper should begin as soon as the cotton is old enough to produce squares and be continued until the crop is set and begins to mature. About 3 or 4 inches of the top of the main-stem terminal of 100 cotton plants per field should be examined. Both adults and nymphs should be counted, the number per 100 terminals

being recorded as the infestation for the field. The examinations should be made at several representative points diagonally across a field, 33 terminal buds being inspected approximately 50 feet from each of the 2 corners and 34 terminal buds at the center of the field.

Cotton Leafworm

The following levels of leafworm infestation, on the basis of ragging and the number of larvae per plant, are suggested for determining damage:

None, if no leafworms are observed.

Light, if 1 or only a few larvae are observed per field.

Medium, if 2 to 3 leaves are partially destroyed by ragging, with 2 to 5 larvae per plant.

Heavy, if ragging of leaves is extensive with 6 or more larvae per plant, or if defoliation is complete.

Pink Bollworm

Inspections to determine the degree of infestation in individual fields should be made as follows:

For infestation of blooms: Early in the season, make infestation counts when there is an average of at least one bloom for every four or five plants, but not more than one bloom for every two plants. Beginning at the margin, walk diagonally across the field and inspect several hundred blooms per field for those rosetted. The number of rosetted blooms should be recorded on a percentage basis.

For infestation of bolls: While walking diagonally across the field, collect at random 100 green bolls that are hard or firm when pressed. Examine each boll as follows: Remove the bracts and calyx by cutting off a thin slice of the base of the boll; cut each section of the boll midway between the sutures so that each lock can be removed intact; examine the inside of the carpel for the characteristic tunnels or mines made by the young larvae. The number of bolls found infested represents the percentage of infestation.

Other inspection techniques: There are other inspection methods besides those listed above that are most helpful in directing control activities against the pink bollworm. These make possible the detection of infestations in previously uninfested areas and the evaluation of increases or decreases in infestation as they occur in infested areas. They are also used to determine the population of larvae in hibernation and the survival or carryover of such larvae to infest the new cotton crop. These methods are as follows:

1. Inspection of gin trash: Procure freshly ginned "first cleaner" trash, which has not been passed through a fan, from as many gins as possible in the area to be surveyed. Maintain the identity of each sample of trash and examine it by separating mechanically all portions of the trash larger and all portions lighter in weight than the pink bollworm. A small residue is left which must be examined by hand. This method is extremely efficient for detecting the presence and abundance of the pink bollworm in any given area. However, it does not usually reveal the exact field or the percentage of field infestation.
2. Inspection of lint cleaner: This is another method for detecting the presence of the pink bollworm. The free larvae remaining in the lint during the ginning process are separated in the lint cleaners and a substantial number of them are thrown and stuck on the glass inspection plates of the cleaners. All larvae recovered from this method are dead. For constant examination at a single gin, wipe off the plates and examine after each bale is ginned. By doing this, the individual field that is infested may be determined. For general survey, make periodic examinations to detect the presence of the pink bollworm in a general area.
3. Examination of debris: Between January and the time squares begin to form in the new crop, examine old bolls or parts of bolls from the soil surface in known infested fields to determine survival of hibernating larvae. Examine the equivalent of 100 bolls and count the living larvae. From these data the number of larvae remaining in hibernation at any given date may be determined. Such records when carried on from year to year provide comparative data which may be used in determining appropriate control measures.
4. Light traps: Especially designed traps using mercury vapor or black light fluorescent bulbs will attract pink bollworm moths. Such traps have been used to discover new infestations and their usefulness and value for survey work should be fully explored.

Spider Mites

In making inspections for spider mite infestation, begin at the margin of the field and while walking diagonally across it examine 100 leaves or more taken successively from near the bottom, the middle, and the top of the plants. The degree of infestation, according to the average number of adult females estimated per leaf, may be recorded as follows:

None	0
Light	1 to 10
Medium	11 to 25
Heavy	26 or more

Thrips

To make inspections for thrips infestations, begin at the margin of the field and while walking diagonally across it observe or inspect numerous plants. The degree of damage may be recorded as follows:

None, if no thrips or damage is found.

Light, if newest unfolding leaves show only a slight brownish tinge along the edges with no silvering of the underside of these or older leaves and only an occasional thrips is seen.

Medium, if newest leaves show considerable browning along the edges and some silvering is evident on the underside of most leaves and thrips are found readily.

Heavy, if silvering of leaves is readily noticeable, terminal buds show injury, general appearance of plant is ragged and deformed, and thrips are numerous.

Supervised Control

Supervised control--a system of field scouting and supervision that has been used for over thirty years--has been increasing in importance in some cotton States. Fields are scouted at least weekly by unbiased and specially trained personnel, and control measures are recommended when necessary. Supervised control makes possible more accurate timing of insecticide applications and helps to eliminate needless treatments. Furthermore, better advantage may be taken of natural and cultural controls. Many farmers have used insecticides unnecessarily because information on the presence of destructive insects was inadequate. This expense has been unwarranted and, sometimes, the treatments have been harmful to beneficial insects. Since the potentially destructive populations may be located before they have had a chance to do any damage, timing of control measures is as near perfect as practically feasible.

Every recommendation is specific for each individual field and all the factors involved are considered in relation to the situation before any recommendations are made.

Extension Educational Program for 1954

There is a serious need for a strong educational program that will present the facts concerning cotton-insect control. This program should be conducted in such a way that everyone interested in cotton

production will be reached. Growers especially need these facts to help them in making plans for 1954.

In order that cotton growers may follow the recommendations made by the State and Federal entomologists without confusion, such recommendations must be basically the same in areas where the insect problems are similar. Points upon which agreement must be reached are (1) the insecticides that are effective, economical, and safe to use with proper precautions, (2) the time to start treatment, (3) the rate of application, (4) the interval between applications, and (5) how to apply the insecticides. Confusion will seriously interfere with effective insect control if these points are not agreed upon.

To facilitate the production of the 1954 crop of cotton, the Extension Service will immediately strengthen and intensify its educational work on the seven-step cotton-production program. To help accomplish the goal each State should have the following committees: (1) A State-wide cotton-production committee made up of representatives from all agencies and organized groups within the State to help develop, promote, and provide leadership to the program; (2) a technical committee made up of representatives from all State and Federal agricultural agencies to prepare recommendations on cotton production and insect control; (3) an extension committee selected by the State Director, which will be responsible for the educational program. Each county or parish should be organized on a basis somewhat comparable to that of the State.

Experience has shown that committees such as those previously outlined play an important part in the planning and carrying out of an integrated program in which all agencies and segments of industry can cooperate. As a result of the cooperative effort, growers will be kept informed of the need for insect control and industry will know better the need for insecticides.

The extension program will stress teaching cotton growers to examine their cotton fields at least once each week to determine the degree of insect infestation. Farmers will also be taught to evaluate their findings in order to apply insecticides effectively and economically.

The following steps, listed on a seasonal basis, outline the extension program that will be carried out in varying degrees in the Cotton States:

Winter

1. State or area meetings with insecticide suppliers and applicators.
2. District meetings with county agents and farm leaders.
3. Through general county meetings, press and radio releases, circular letters, and posters, stress the cotton-insect control program. Also encourage growers to arrange for the

purchase of insecticides and to get equipment in shape for next season.

4. Secure the cooperation of farm loan agencies, oil mills, ginneries, fertilizer associations, and other groups concerned with the production of cotton.

Spring

1. Release information from surveys by State and Federal entomologists on boll weevil survival.
2. Continue meetings on cotton-insect control.
3. Demonstrate procedure for making cotton-insect counts per acre in order to determine when and where early boll weevil control is needed.
4. Issue recommendations on early-season cotton-insect control.
5. Conduct 4-H Club and other youth meetings devoted to cotton insects and their control.

Summer

1. Survey information releases on insect infestation.
2. Field demonstrations on insect identification, infestation counts, and proper application of insecticides.
3. Timely radio programs, newspaper articles, and circular letters on insect conditions and control.
4. Field tours to study demonstrations and experiments on cotton-insect control.
5. Daily radio reports on weather conditions.

Fall

1. Stress importance of defoliation in preventing insect damage to young bolls.
2. Promote an early stalk destruction program to reduce insect populations, in areas where this is feasible.

Educational Tools

Full use should be made of the following educational tools to stimulate the adoption of recommended practices:

1. Publications--yearly recommendations.
 - A. Plan of organizational set-up showing responsibility of each agency.
 - B. Yearly recommendations for insect control.
2. Mimeographed informational material.

3. Posters, charts, exhibits at fairs, models.
4. Magazine articles.
5. Cotton letter or other circular letters.
6. Newspaper publicity, special editions.
7. Radio spot announcements and recordings. Sponsored program at set time and day each week to build up a listening audience for the program.
8. Public meetings.
9. Individual contacts.
10. Slides and motion pictures.
11. Television where available.
12. Equipment displays at method demonstrations.
13. Result demonstrations.
14. Visits to Experiment Stations.

Needed Research

Additional information is needed on the life history, habits, biology, ecology, host plants, natural enemies, and control of each of the insects and mites injurious to cotton that are mentioned in this report, especially in areas and under conditions where extensive studies have not been conducted.

Under present conditions in the United States every effort should be made to expand and improve the research relating to the pink bollworm, the bollworm, the tobacco budworm, the boll weevil, spider mites, thrips, and cutworms injurious to cotton. Every phase of natural, cultural, mechanical, and chemical control should receive attention. Special phases of cotton-insect research suggested by this conference are grouped under the seven headings given below. Each of these groups is interrelated with problems covered by other groups and progress in one problem often contributes to the progress in others. Under each heading is listed lines of research in which additional information is especially needed.

1. Insecticides and miticides.

A. New and improved materials and equipment.

- a. Evaluation of new toxicants and mixtures of toxicants, solvents, emulsifiers, and dust diluents under the varying conditions of cotton production.
- b. Design of machinery and equipment for more effective application of sprays and dusts.
- c. Relation of temperature, humidity, sunlight, rainfall, and air currents to the effectiveness of insecticides.
- d. Relation of coverage, particle size, distribution, adherence, and residual toxicity of insecticides to cotton-insect control.

- e. Factors influencing the deterioration of insecticides in storage.
- f. Improved techniques for testing insecticides.
- g. Establish criteria for suitable dust mixtures of organic insecticides.
- h. Systemic insecticides.
- B. Improved timing of treatments in relation to--
 - a. Development and fruiting of the cotton plant.
 - b. Early-season control and the subsequent development and yield of cotton.
 - c. Value of community action in controlling cotton insects.
 - d. Seasonal development, life histories, and habits of the major cotton pests and others that are potentially injurious.
- C. Effects of pesticides on plants, soils, and animals.
 - a. Upon the physiological and phytotoxic reaction of cotton plants.
 - b. Upon soils and subsequent crops when applied to cotton.
 - c. Upon natural enemies of cotton insects.
 - d. Upon livestock, poultry, wild life, and man.
 - e. Upon honey bees and other pollinating insects.
 - f. The possibility of contaminating food and feed processed from cotton previously treated with organic insecticides and by drift to other crops when applied for the control of cotton insects.
- 2. Improved methods of forecasting damage by cotton insects and mites.
 - A. Through improved methods of determining infestations.
 - B. Through studies of ecological factors, cropping systems, natural enemies, cultural practices, plant nutrition, and migration.
- 3. Combining insect control with other operations in mechanized production of cotton. Use of shredders and larger and better plows.
- 4. Defoliation in relation to the control of cotton insects.
- 5. Parasites and predators of cotton insects and mites.
- 6. Diseases of cotton insects and mites.
- 7. Physiological, biochemical, and nutritional studies on cotton insects.
 - A. The physiological mode of action of pesticides on insects and mites.
 - B. The effect of sublethal dosages of insecticides upon insect reproduction and development.
 - C. The possibility of the development of insect resistance to insecticides.

8. Coordination of observations and studies of cotton-insect activities and distribution on an international basis--for example, the migration of the cotton leafworm.
9. Insect-resistant varieties.
10. Modifications of gin and mill equipment to kill pink bollworms.
11. Relationship of cotton insects to diseases of cotton.
12. Evaluation of factors other than parasites and predators in cotton-insect control.
13. Hibernation studies of major cotton pests.
14. Relation of gamma and other isomer content of benzene hexachloride to aphid control.

Conferees at Seventh Annual Conference, December 14-15, 1953

Eighty-nine entomologists and associated technical workers concerned with cotton-insect research and control participated in the Cotton Insect Research and Control Conference held at Memphis, Tenn., December 14 and 15, 1953. They were from the Agricultural Experiment Stations, Extension Services, and other agencies in 15 cotton-growing States, the United States Department of Agriculture, and the National Cotton Council of America. The statements in this report were agreed upon and adopted by the following conferees:

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P.H. Smith, Farmer cooperater, Smith Farms, Slocomb

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